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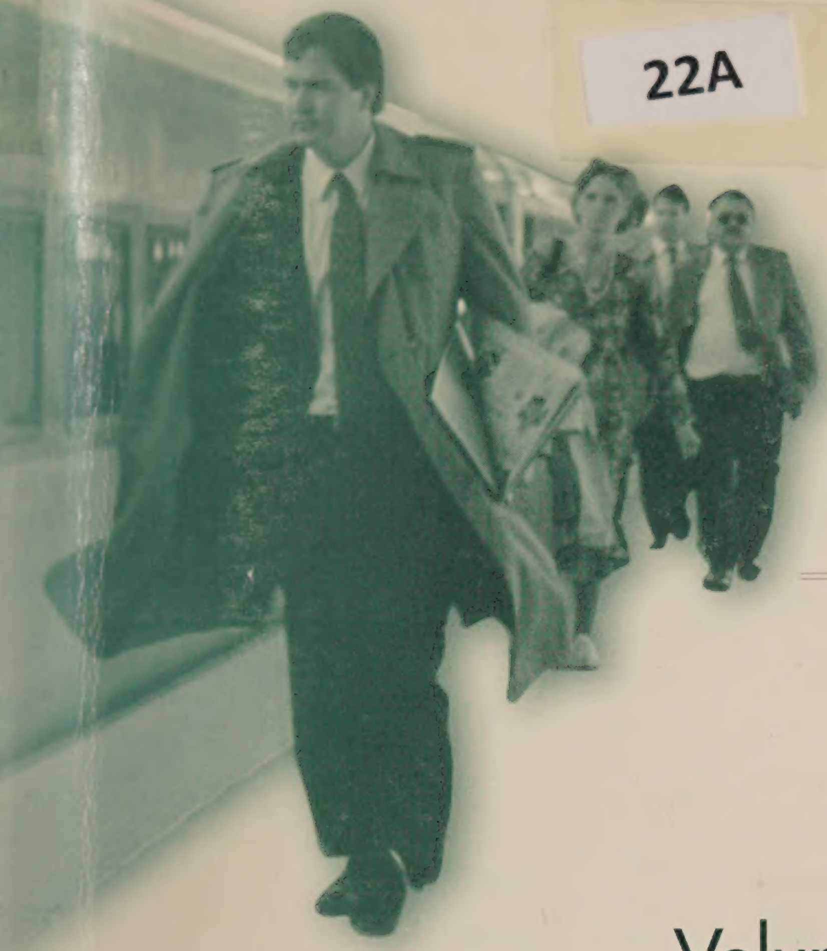


Draft Environmental Impact Report

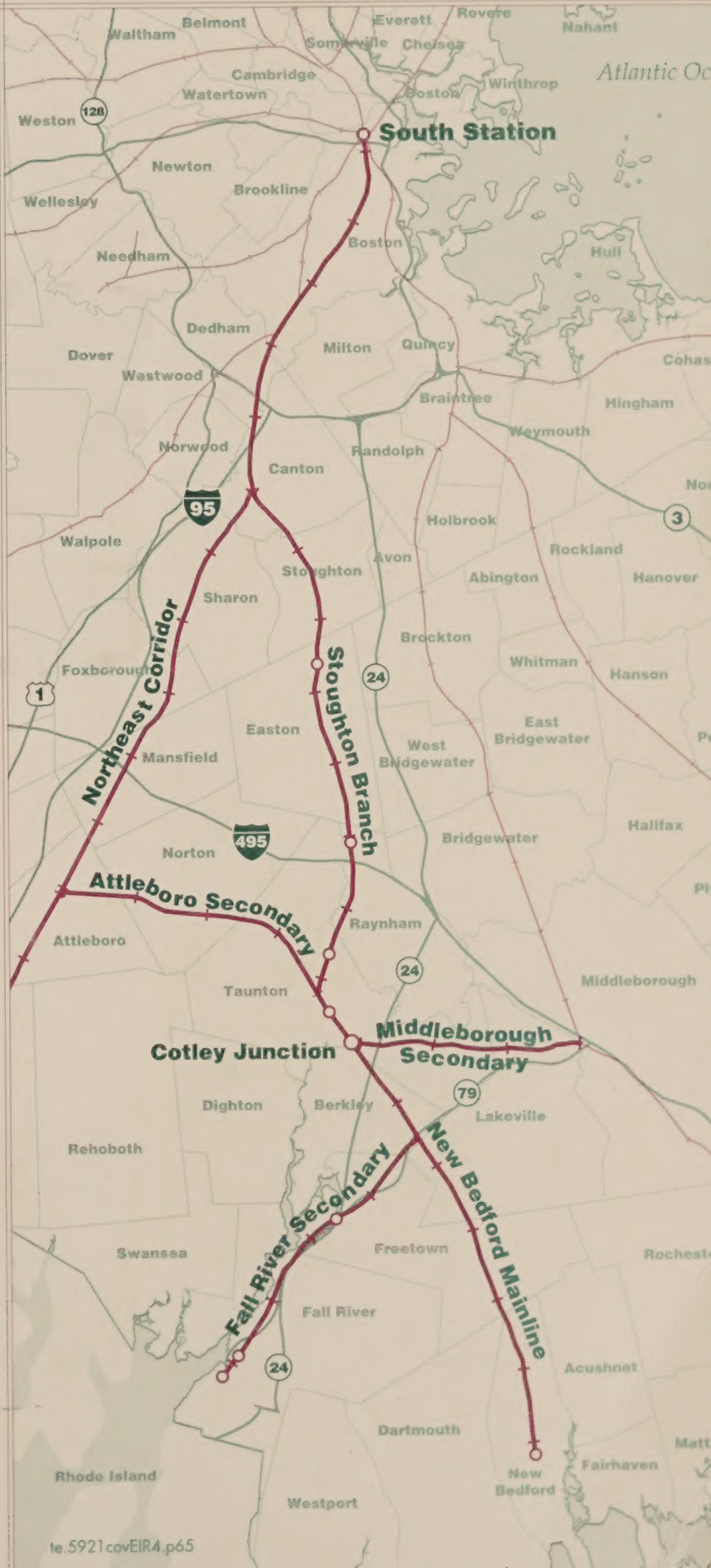
Volume III
Appendices

New Bedford/ Fall River
Commuter Rail Extension

July 1999

Submitted by:

Massachusetts Bay
Transportation Authority



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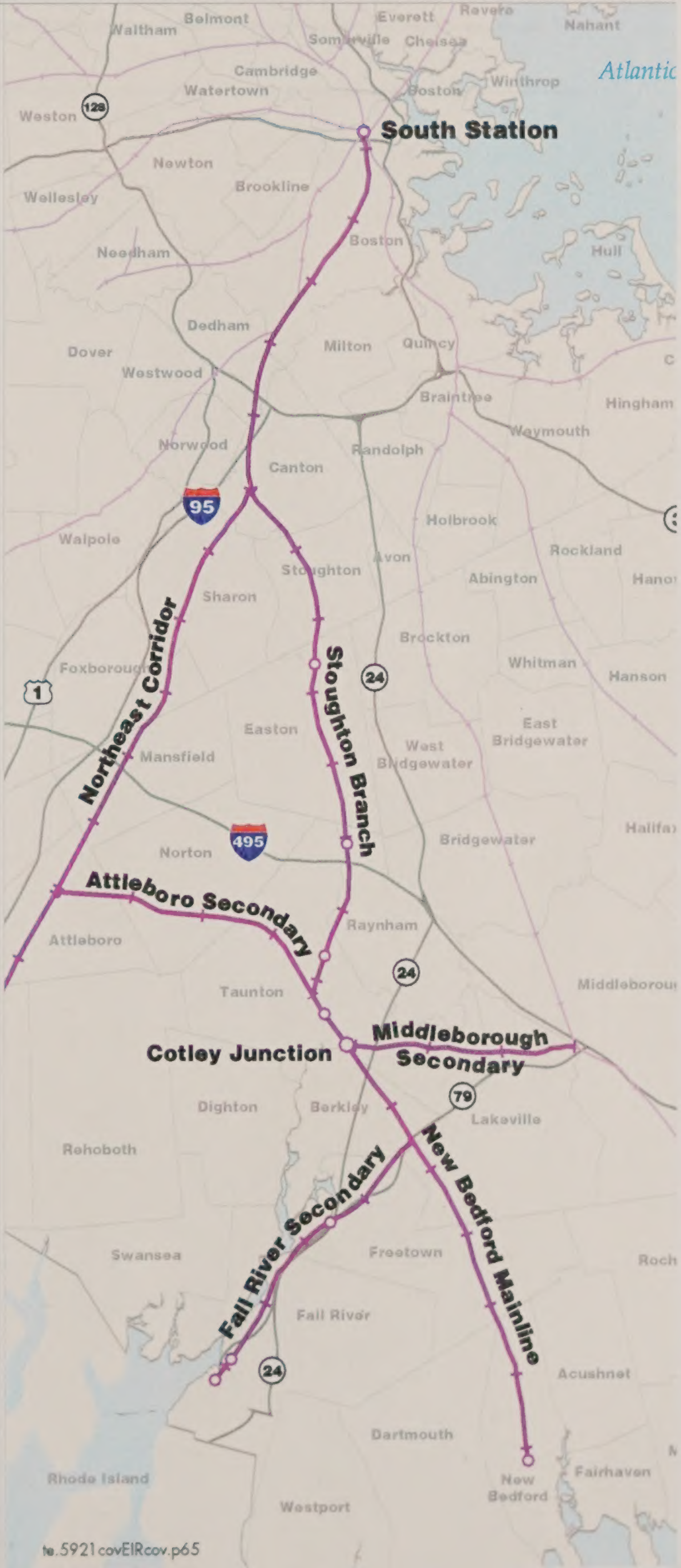

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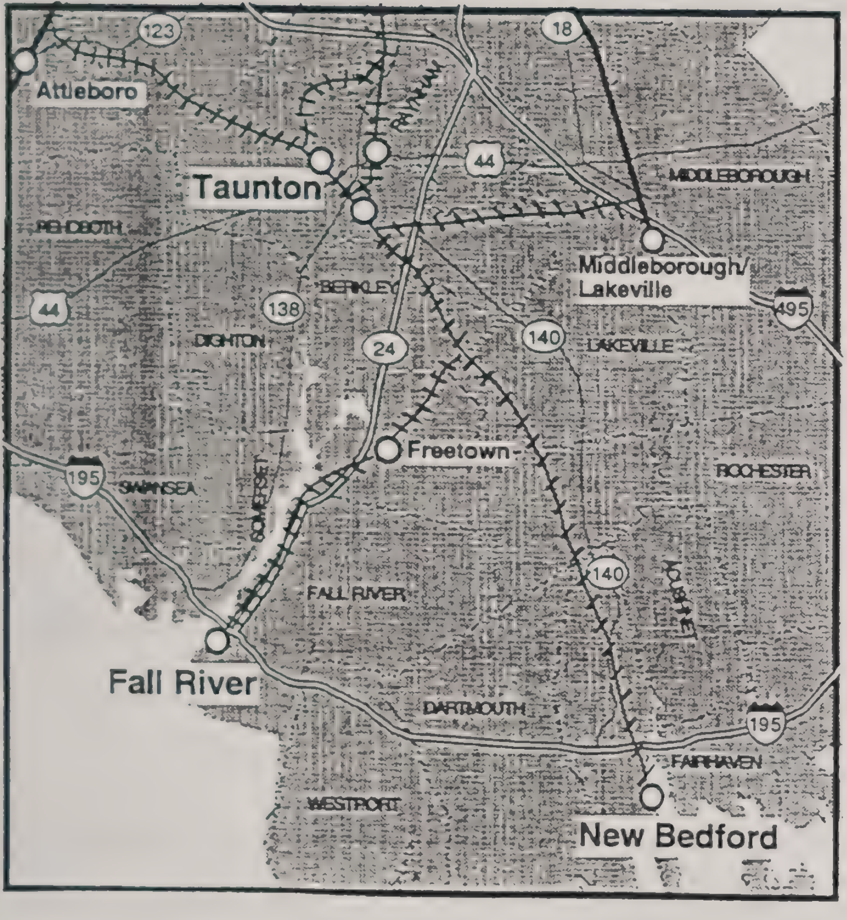

Expanded Alternatives Analysis

prepared for the
Massachusetts State
Legislature

March, 1997

Prepared by the

Massachusetts Bay
Transportation Authority

in cooperation with

Central Transportation Planning Staff
Vanasse Hangen Brustlin, Inc.
LS Transit Systems, Inc.
Sverdrup Civil, Inc

NEW BEDFORD / FALL RIVER COMMUTER RAIL EXTENSIONS
EXPANDED ALTERNATIVES ANALYSIS

Executive Summary

In May, 1995, the Massachusetts Bay Transportation Authority (MBTA) completed an *Expanded Feasibility Study* to evaluate the potential for extending commuter rail service to the southeastern Massachusetts communities of New Bedford, Fall River and Taunton. Following public comment and review of this study, the MBTA initiated engineering and design work to construct a rail extension via the so-called Attleboro route. This effort was stopped in January, 1996, in response to concerns expressed by communities along the proposed right-of-way.

In August 1996, the Massachusetts State Legislature directed the MBTA to further study all viable alternatives for extending commuter rail service to both New Bedford and Fall River. This report is prepared in response to this directive and includes the cost, projected ridership and a proposed operational scenario for each alternative. An assessment of the potential impacts of each alternative is also included.

Alternatives Considered

Eight commuter rail alternatives, running along three alternate routes, and an enhanced commuter bus option were considered.

Route	Alternatives	Description
via Attleboro	1A and 1B	Extension would branch from the MBTA's Attleboro line north of Attleboro station; use a $2^1/_2$-mile bypass to connect to the Attleboro Secondary; and serve two Taunton stations before branching to New Bedford and Fall River.
via Middleborough	2A, 2B, 2C and 2C-1	Service would be extended from the Middleborough/ Lakeville terminal now being constructed as part of the Old Colony project. The line would follow the Middleborough Secondary and serve one Taunton station before branching to the south.
via Stoughton	3A and 3B	Involves an extension of the MBTA's Stoughton Branch. Service would be provided to Easton, Raynham, and Taunton before branching to New Bedford and Fall River.
via Commuter Bus	4	Involves improvements to the existing commuter bus services now operating from New Bedford, Fall River and Taunton.

Alternative 1A via Attleboro and Alternative 3A via Stoughton consider the addition of New Bedford/Fall River service along the existing MBTA Attleboro or Stoughton lines; these options are similar to those evaluated in the 1995 study. Ridership and cost estimates differ from the 1995 results due to the fact that service plans have been modified and more detailed engineering has been performed.

Alternatives 2A, 2B, 2C and 2C-1 consider extending service along the Middleborough branch of the Old Colony system. In response to the legislative directive, these options each provide service to *both* New Bedford and Fall River. These Middleborough line alternatives were designed to test the feasibility of: extending Old Colony service (Alternative 2A); adding more service on the Old Colony Main Line (Alternative 2B); relocating Lakeville station to provide faster service (Alternatives 2C and 2C-1); and, using a shuttle service to supplement service levels south of Taunton (Alternatives 2B and 2C-1).

Alternatives 1B and 3B considered the use of diesel-multiple units (DMUs) in an effort to operate more cost-effective service and to reduce the amount of traffic along the right-of-ways. DMUs are conventional passenger coaches equipped with diesel engines.

Summary of Results
The analysis results for each route are shown in **Table E-1** and summarized below:

> **Attleboro** Compared to the 1995 Feasibility Study, ridership is somewhat reduced and costs have increased. Daily inbound boardings would be 3,230 (versus the 3,940 projected in 1995) because of a slight reduction of capacity on the Northeast Corridor. Cost increases can be attributed to the need for double track and grade separation on the bypass; replacement rather than upgrade of track; and more advanced signal requirements. Total project cost is estimated to be about $407 million, including equipment, design, land acquisition and contingencies.
>
> **Stoughton** This route would have the highest ridership, with 4,325 inbound boardings. Total project cost is estimated to be $410 million, or in the same range as Attleboro. The Stoughton right-of-way passes through the Hockomock Swamp Area of Critical Environmental Concern in Rayhnam. Extension via this route would require special project designation by the Executive Office of Environmental Affairs (EOEA) and would be difficult to permit.
>
> **Middleborough** Four alternatives were considered. The alternatives that offer the highest levels of service attract about 2,045 riders. Ridership on Middleborough extensions is lower mainly because Back Bay station, where 40 percent of southside

MBTA riders disembark, is not served. More importantly, there are several operational issues which diminish the feasibility of an extension along this alignment.

Middleborough options that simply extend Old Colony service (2A, 2C and 2C-1) would not be able to accommodate both New Bedford/Fall River and Old Colony passengers. The addition of New Bedford/Fall River passengers onto Old Colony trains would require some trains to carry 27 percent more passengers than their seating capacity. Additional trains would need to be run to accommodate all passengers.

The concept of adding New Bedford and Fall River trains to the Old Colony system was tested under Alternative 2B. The results show that the 9.8 mile segment of single-track north of Braintree results in a highly constrained operating environment and effectively precludes the addition of New Bedford/Fall River service. Simulations have demonstrated that increased train traffic would have significant impacts on the level of service provided to Old Colony passengers. Minor delays would have the potential to dead-lock service throughout the entire Old Colony system affecting the daily commute for more than 15,000 south shore commuters.

To overcome Old Colony capacity constraints and to add service for New Bedford/Fall River passengers, the MBTA would need to double track the Old Colony line north of Braintree. This would add $100 million in capital costs and an undetermined, yet likely significant, amount for property acquisition and relocation. This investment would have a minimal impact on New Bedford/Fall River ridership, but would make this alignment the most expensive to construct, with total project costs exceeding $436 million.

DMU Options The feasibility and cost-effectiveness of diesel multiple unit (DMU) operations are inhibited by current federal safety regulations. Current requirements dictate a 7 to 12 minute delay for passengers on trains that would “couple” together at East Taunton station. The use of DMU technology to serve as shuttles between Fall River, Taunton and New Bedford would be, however, a relatively cost-effective means of augmenting branch service where main line capacity is constrained.

Enhanced Commuter Bus This alternative would increase bus headways, expand commuter parking, and provide bus passengers with the same fare and transfer benefits as rail passengers. Because bus travel times are generally equal or better to commuter rail travel times, ridership would be relatively high. An estimated 3,500 commuters would use this improved service, an increase of about 2,050 daily. Total project costs would be $22 million. Analysis shows that the increase in fare revenues from these changes would exceed the incremental cost in bus operations.

TABLE E-1
Summary of Alternatives ($1996)

Alt. No.	Description	Daily Inbound Boardings	Total Project Cost[1]
1A	NB/FR via Attleboro	3,230	$407 m.
1B	NB/FR via Attleboro - DMU Service	2,970	$406 m.
2A	NB/FR via Middleborough	1,320	$293 m.
2B	NB/FR via Middleborough - Skip Stop, Shuttle/Transfer	2,045	$436 m.[2]
2C	NB/FR via Middleborough - Relocated Lakeville Station	1,410	$305 m.
2C-1	NB/FR via Middleborough - Relocated Lakeville Station, Shuttle/Transfer	2,030	$309 m.
3A	NB/FR via Stoughton	4,325	$410 m.
3B	NB/FR via Stoughton - DMU Service	3,890	$421 m.
4	Enhanced Bus Service	3,500	$22 m.

1. Total Project Costs = Infrastructure, Equipment, Land Acquisition, Engineering/Design and Contingencies.
2. Total Project Costs for Alternative 2B do not include land acquisition and relocation north of Braintree.

Conclusions

The Stoughton route would attract the highest ridership and represents the most cost-effective commuter rail alternative. The attractiveness of this route is due mainly to the ability to serve a new North Easton station where more than 1,000 passengers would board daily. However, the presence of an Area of Critical Environmental Concern would make this alternative difficult to permit. The Attleboro route attracts slightly less ridership than the Stoughton route, yet would be preferable from an environmental perspective.

Extensions of Old Colony service from Middleborough would not be feasible without increasing train traffic on the tightly constrained Main Line north of Braintree. The scheduling of additional trains along this 9.8 mile segment of single-track would have significant operational impacts on all branches of the Old Colony system. Simulations have shown that virtually all peak-period service would be delayed, and potentially deadlocked.

The construction of a second track north of Braintree would make this route a feasible alternative, but it would not bring Fall River/New Bedford ridership up to the levels projected along the Attleboro or Stoughton routes. Furthermore, the costs associated with double tracking would make an extension via Middleborough the most expensive and least cost-effective option. The complexity of double tracking along this densely developed corridor, and the potential magnitude of residential and business relocations in Quincy and Dorchester, cannot be overstated.

The Attleboro and Stoughton routes are the only options that would attract ridership levels that are comparable to those found on existing MBTA commuter rail lines. This expanded alternatives evaluation attempted to generate increased ridership along the Middleborough route by adding more trains to the Old Colony system, running supplemental shuttle service for New Bedford and Fall River passengers, and considering the relocation of Middleborough/Lakeville station. These approaches resulted in Middleborough line alternatives with ridership levels that were still 35 to 50 percent less than found on the Attleboro or Stoughton routes.

NEW BEDFORD / FALL RIVER COMMUTER RAIL EXTENSIONS
EXPANDED ALTERNATIVES ANALYSIS

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I. INTRODUCTION

A. BACKGROUND

Until 1958, commuter rail service from South Station to New Bedford and Fall River was operated via Canton, Stoughton and Taunton. Current MBTA service along this route now operates only as far as Stoughton. Additional service to southeastern Massachusetts is also provided to Providence, via Attleboro (see **Figure 1**). Commuter rail service along the Old Colony lines to Middleborough and Plymouth will be restored in September 1997. The remainder of Southeastern Massachusetts is served by three major bus carriers.

This report evaluates the feasibility of reestablishing passenger train service between New Bedford, Fall River, Taunton and Boston as a way of mitigating against traffic congestion and improving access to Boston.

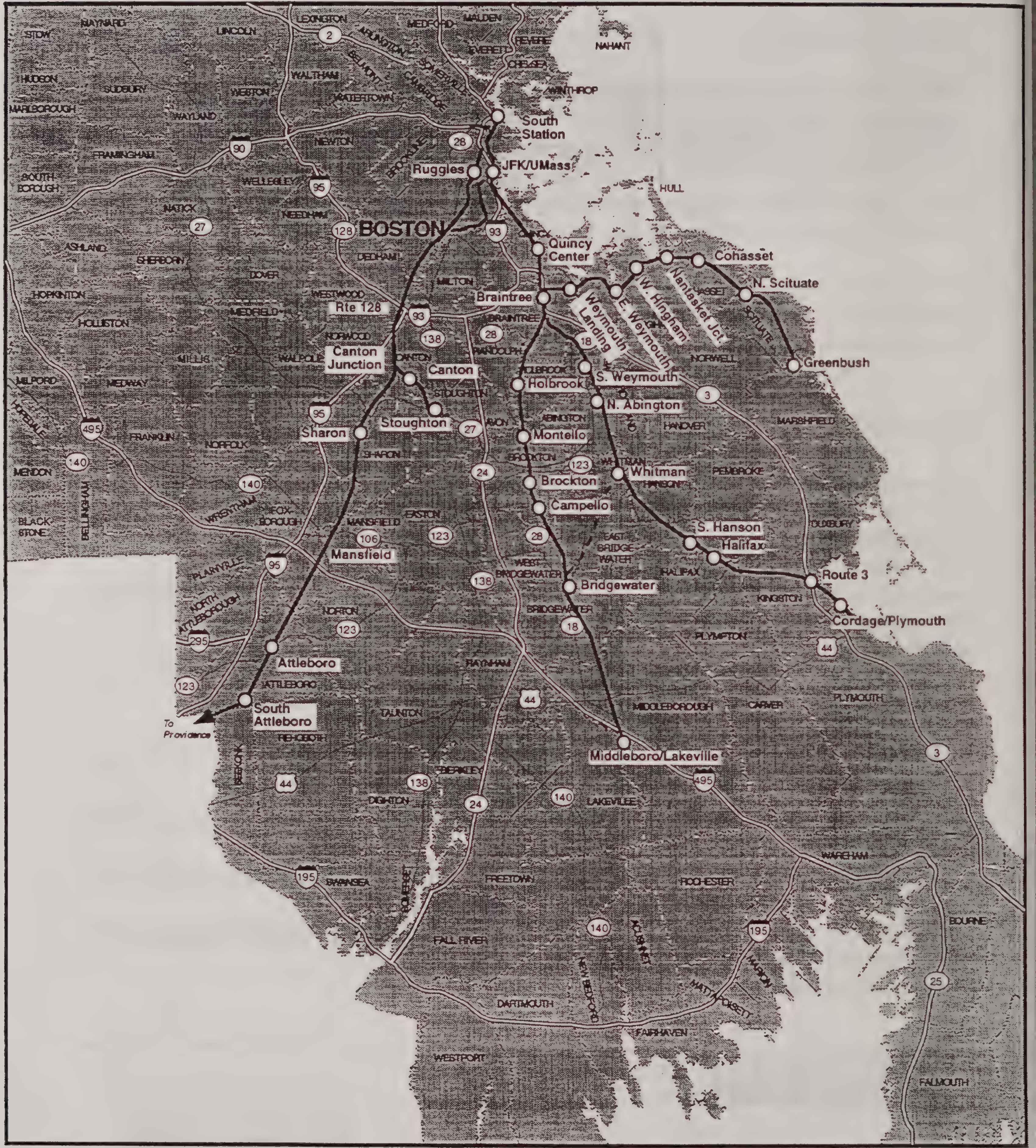
B. PREVIOUS STUDIES

In January 1990, MBTA published a study entitled *Commuter Rail Extension Feasibility Study - New Bedford/Fall River* (Louis Berger & Associates). The study recommended that service on the Stoughton Branch be extended to New Bedford and Fall River. However, prior to the MBTA's commencement of design and environmental analysis of the extension, a number of issues were raised by the Joint Transportation Planning Group (JTPG) of the Southeastern Massachusetts Metropolitan Planning Organization. These concerns resulted in the identification of several alternatives that had not been previously considered, or that required additional review.

In response to the JTPG, the MBTA completed an *Expanded Feasibility Study* in May, 1995. The following alternatives were considered:

- Four alternatives extending the Old Colony Middleborough Line to either Fall River or New Bedford, but not both;
- Two alternatives extending the Stoughton Branch to either North Easton or to both Fall River and New Bedford;
- One alternative branching from the Northeast Corridor Main Line (NEC) in Attleboro to both Fall River and New Bedford, and;
- Enhanced commuter bus service.

Figure 1
Existing and Planned MBTA Commuter Rail Services in Southeastern Massachusetts



The report found that, while construction costs for the Middleborough alternatives would be reasonable, ridership would be lower than all other alternatives due to longer travel times and the inability to stop at Boston's Back Bay Station. Furthermore, due to capacity constraints on the Old Colony system, it was assumed that service to both New Bedford and Fall River could not be provided without sacrificing desired service levels. The Stoughton alignment had the highest ridership, but also the highest cost.

Following a series of public presentations, the Attleboro alignment was selected as the preferred alternative because it was viewed as having the best balance of cost and benefits. It had high ridership, reasonable capital costs and travel times competitive with automobile trips. It was also viewed as having lower environmental and community impacts than a Stoughton alignment.

In September 1995, the MBTA initiated engineering studies to construct an extension of commuter rail service to the cities of Taunton, New Bedford and Fall River. This extension was proposed to be constructed as a branch from the existing MBTA Attleboro Line, to use the Attleboro Secondary track through Norton and Taunton, and to branch south of Taunton to provide full service to both New Bedford and Fall River. The service would have made use of existing and active railroad right-of-ways, with the exception of a new 2-$^1/_2$ mile bypass along a utility right-of-way in Attleboro.

The MBTA submitted an Environmental Notification Form for the Attleboro alignment in October 1995. This submission raised a number of local concerns regarding the construction of a 2$^1/_2$-mile bypass along new right-of-way in Attleboro and regarding increased levels of train traffic through Norton and at grade crossings in Taunton. These concerns were also expressed by state legislators and at a number of local community meetings held by the MBTA. In response, the MBTA stopped work on the project in January 1996.

C. 1996 LEGISLATIVE DIRECTIVE

In August 1996, the State Legislature adopted the 1996 Transportation Bond Bill and called for the MBTA to further study all viable alternatives for extending commuter rail service to both New Bedford and Fall River. This report is prepared in response to the legislative directive (Chapter 205, Section 2J), and includes the cost, projected ridership and proposed operational scenario for each alternative, as well as an assessment of potential environmental impacts, grade crossings and other public safety considerations.

The objective of this report is to present a more detailed examination of the feasible alternatives and to assist state legislators, the affected communities and the MBTA in achieving consensus on a preferred route for commuter rail service.

This report focuses primarily on the three alternative routes running as far south as Cotley Junction in Taunton. From Taunton to New Bedford and Fall River there are not any significant differences between the alternatives. Nine different alternatives are evaluated in this report: two via Attleboro, four via Middleborough, two via Stoughton, and a commuter bus option.

Alternatives 1A and 3A are similar to options studied in the 1995 Feasibility Study. Alternatives 1B and 3B consider the use of diesel multiple unit (DMU) vehicle technology. Alternative 2A represents an extension of Old Colony Middleborough service, with alternating trains between the two terminals. To reduce the travel time via Middleborough, Alternatives 2C and 2C-1 consider relocating the Old Colony Middleborough/Lakeville terminal that is now under construction. Also, to provide additional service on the tightly constrained Old Colony system, Alternatives 2B and 2C-1 evaluate the use of more innovative operating plans.

All alternatives would include stations at New Bedford, Fall River, Freetown and East Taunton. Attleboro routed service would also include a station at Taunton Center. Stoughton service would include new stations at Dean Street/Taunton, Raynham and North Easton. For the Middleborough alternatives, an alternative East Taunton station was located off of Stevenson Street and an alternative Middleborough/Lakeville station was located near Routes 18 and 79.

II. ALTERNATIVES CONSIDERED

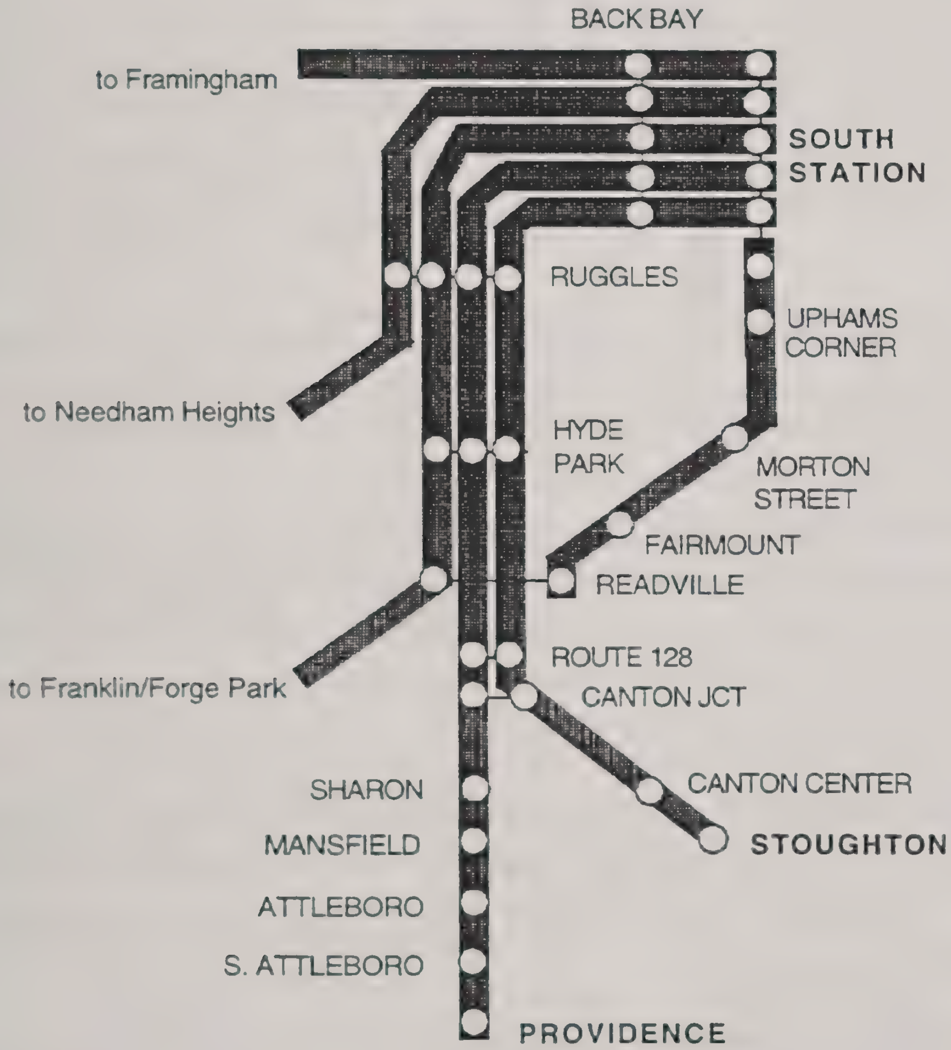
A. SUMMARY OF EXISTING CONDITIONS

Existing Transit Services in the Study Area

Passenger rail service in the study area is currently provided from South Station only as far as Stoughton via the Stoughton Branch and to Providence, Rhode Island, via Attleboro. These services are shown in Figure 2.

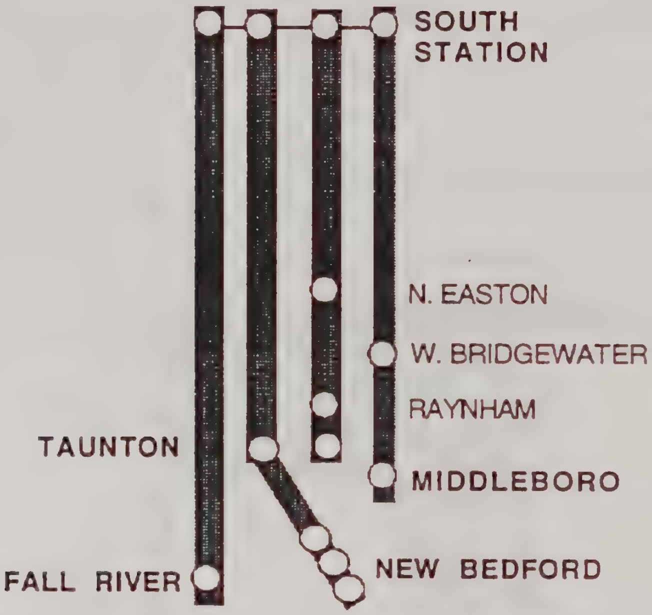
FIGURE 2

Existing MBTA Commuter Rail Service from South Station



The remainder of southeastern Massachusetts is serviced by three major bus carriers. Current bus routes between the study area and downtown Boston are shown in Figure 3. Of the communities being considered for new commuter rail stations, only Freetown is not currently served by commuter bus service to Boston.

FIGURE 3
Existing Commuter Bus Service in Southeastern Massachusetts



American Eagle Motor Coach operates a route between New Bedford and Boston, serving several intermediate park & ride facilities. This route runs 16 inbound and 17 outbound weekday trips. Headways range from 15 to 40 minutes in the peak period, and about two hours in the off-peak. The scheduled running time inbound between downtown New Bedford and downtown Boston is 1 hour, 45 minutes on most peak trips, and 1 hour, 30 minutes on most off-peak trips.

Bonanza Bus Lines operates a route from Fall River to South Station with most trips originating from Newport, Rhode Island. At present, there are eight round trips on weekdays, and six on Saturdays and Sundays. The scheduled inbound running time is 1 hour, 5 minutes for peak trips, and 1 hour for off-peak trips.

Bloom's Bus Lines, Inc. operates a route from Taunton to Boston, also serving parts of Raynham and Easton. At present, 16 inbound and 15 outbound trips are run on weekdays. The scheduled running time inbound in generally 1 hour 10 minutes during the peak period. Middleborough buses are operated by Interstate Coach. These trips serve the Bridgewater, Middleborough, Stoughton, Easton and Boston.

Planned or Proposed Transportation Services in the Service Area

Several transportation improvement projects that may benefit commuters in the greater New Bedford/Fall River area are currently under construction or planned as part of the region's long range transportation planning process.

Old Colony Commuter Rail Project

The Old Colony Commuter Rail Project involves the restoration of commuter rail service on the Middleborough, Plymouth and Greenbush Lines. The Middleborough and Plymouth lines are now under construction and will be operational in September of 1997. The Supplemental Final EIR report and preliminary engineering plans are now being prepared for the Greenbush line.

All three Old Colony lines merge in Braintree and proceed north to South Station on a shared 9.8 mile one-track system known as the Main Line. The Main Line has two passing tracks, constructed as part of the Old Colony, project to maximize capacity to the greatest extent possible without incurring an estimated $100 million in costs for double tracking and further costs for land acquisition and relocation. Since the last feasibility study, two new commuter rail stations are being incorporated into the Old Colony system along the Main Line at Quincy Center and JFK/UMass.

The Middleborough Line extends for approximately 25 miles, serving seven stations, from Braintree to the Middleborough/Lakeville terminal. The Line is single track with four passing tracks. These passing tracks have been located to optimize operations on the Old Colony system. Although the service plan for the year 2000 assumes six-car trains, platforms have been designed to accommodate nine-car trains. The Middleborough/Lakeville station is located about one-mile south of the Middleborough Wye/Middleborough Secondary junction where trains to Fall River and New Bedford would diverge to the west.

Highway Improvements

Planned highway improvement projects include the Central Artery/Third Harbor Tunnel project, the completion of Route 44 improvements, the widening of Route 128 (I-93/I-95) between Randolph and Wellesley, and the widening of Route 3 between Weymouth and Duxbury.

MBTA Commuter Parking Expansion Program

As part of the Central Artery Mitigation Program, it is required that 20,000 commuter parking spaces be built between 1991 and 1999. Planned expansions in southeastern Massachusetts include additional commuter parking in Quincy, South Attleboro, Mansfield, Sharon, Walpole, Norwood and Route 128 as well as the new spaces being developed as part of the Old Colony project.

Proposed Commuter Rail Service to Bourne
In September 1996, the MBTA completed a study which considered the feasibility of extending Middleborough Line trains further south along existing trackage to the Cape. Amtrak currently uses this route via Attleboro, for summer service to the Cape. Capacity constraints that would limit the routing of both New Bedford/Fall River and Bourne trains through Middleborough are discussed later in this report.

B. DEFINITION OF ALTERNATIVES

This expanded alternatives analysis is prepared in response to a legislative directive that specified that the feasibility of the Middleborough, Attleboro and Stoughton alignments be re-examined. Several operational plans were considered for each of these routes. In addition, the enhanced commuter bus alternative is updated and refined for comparison purposes. It is important to note that, although much of Fall River and New Bedford rail service would operate as one line, there would be two outlying branches. It is not possible to effectively serve both cities with one line, unless diesel multiple unit technology or cross platform transfers are utilized.

The No-Build alternative constitutes the baseline representing no action and against which all the other alternatives are evaluated. Furthermore, all rail alternatives assume that existing commuter bus service will remain as currently operated and Old Colony commuter rail service will operate as currently planned and permitted.

Alternative station sites were not evaluated unless station location had a direct effect on operational feasibility. This was the case for two stations along the Middleborough alignment in East Taunton and Lakeville, and for a relocated Taunton station along the Stoughton alignment. Site evaluation criteria for station siting includes: highway access, railroad operations, environmental issues, consistency with community objectives, cost and constructibility.

No-Build Alternative

The No-Build alternative constitutes the baseline against which all the other alternatives are evaluated. This alternative includes existing transportation facilities and services, as well as committed facilities and services that will be completed by the year 2010. Assumptions include completion of the Central Artery/Tunnel project, completion of Route 44, Route 128 widening between Routes 24 and 9, Route 3 widening between Weymouth and Duxbury, an additional 2,700 parking spaces along the Attleboro and Franklin commuter rail lines, an additional 1,300 spaces at the Quincy Adams Red Line station, an additional 300 spaces at the Hingham commuter boat terminal, construction of additional maintenance and storage facilities. Also included in the committed services are implementation of service along the three Old Colony commuter rail lines and completion of the South Boston Piers Transitway project. The model assumes a ten-minute travel time savings for High Occupancy Vehicles (HOV's) using the HOV lane on the Southeast Expressway.

Alternative 1A: New Bedford and Fall River via the Attleboro Line Alternating Standard Train Consists

This alternative was studied in detail as part of an Environmental Notification Form submitted to the Executive Office of Environmental Affairs in October, 1995 (see **Figure 4**). It would follow the MBTA Attleboro Shore Line from South Station to a point just north of Attleboro station. A 2½-mile double track bypass would be constructed along a power line right-of-way in northeast Attleboro to connect with the Attleboro Secondary heading towards Taunton. The service would travel through Norton, Taunton Center and Cotley Junction, diverging at Myricks Junction in Berkley. One branch would continue to New Bedford along the New Bedford Secondary. The second branch would use the Newport Secondary to serve Freetown and Fall River. The total extension would be about 42 miles.

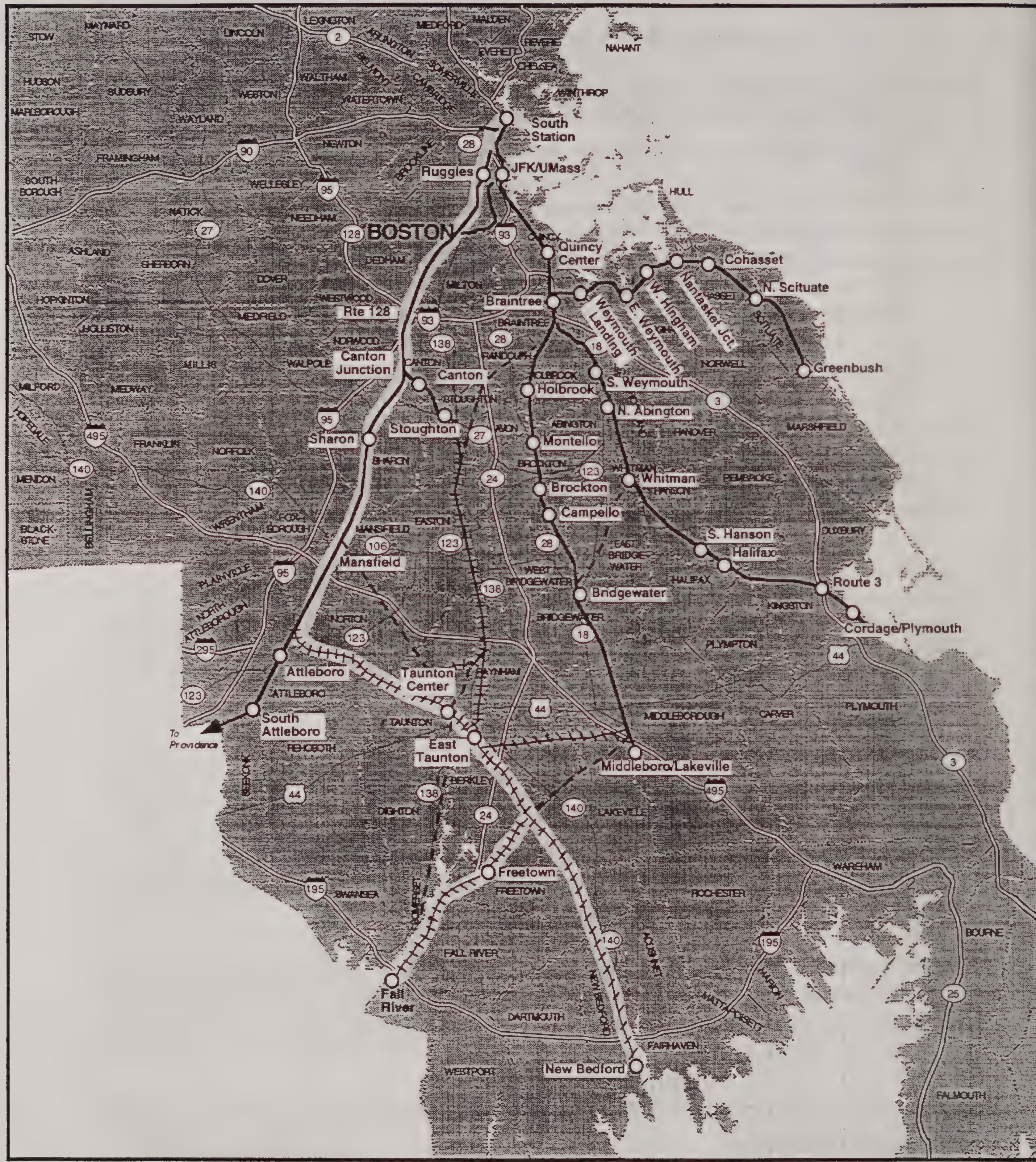
Trains from New Bedford and Fall River would interface with Attleboro/Providence trains and Amtrak high-speed inter-city trains between Attleboro and South Station. Track conditions and capacity along the Attleboro Main Line were assumed to be consistent with Amtrak's Northeast Corridor (NEC) Master Plan. Track capacity in the corridor was evaluated in detail as part of this study. This analysis concluded that additional capacity in the range of 36 trains daily was available for New Bedford and Fall River service.

Freight service now operates along the Attleboro, New Bedford and Newport Secondaries. Track replacement would be required along the Attleboro Secondary to increase speeds and improve grade crossings. South of Cotley Junction, complete rebuilding of the New Bedford and Newport Secondary Tracks would also be required. A double track connection is required at the Attleboro bypass to enable the smooth transition of trains on and off the Northeast Corridor.

Service to both New Bedford and Fall River would be operated in addition to the existing service on the Attleboro Line (see **Figure 5**) and would replace Attleboro line stops at Sharon. All New Bedford/Fall River trains would stop at East Taunton, Taunton Center, and Sharon. The East Taunton station would be a major park-and-ride facility, located just northwest of Cotley Junction and the intersection of Routes 24/140. Trains from Fall River would also stop at Freetown. From Sharon, the trains would run express to Ruggles Station, then serve Back Bay and South Station. Providence trains would skip the Sharon stop.

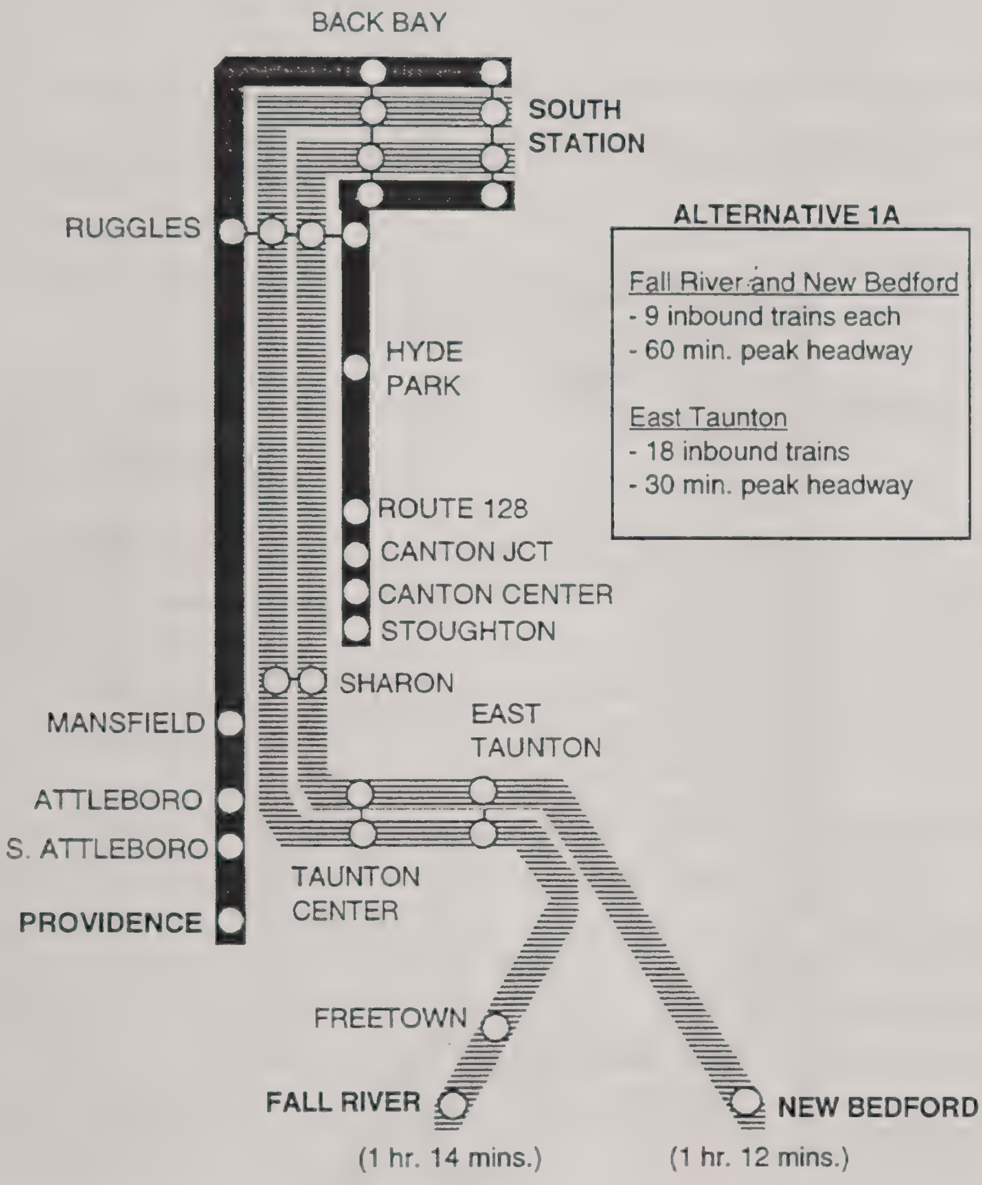
Eighteen daily trains would serve each terminal. Travel time from Fall River to South Station would be 1 hour and 14 minutes and from New Bedford would be 1 hour and 12 minutes. Service would be provided from each city every 60 minutes during the peak periods.

Figure 4
Commuter Rail Service to New Bedford and Fall River via Attleboro
Alternatives 1A and 1B



This alternative is similar to that proposed for implementation in the summer of 1995. The only difference is that, based on a detailed operational analysis, the level of service has been reduced from 22 trains serving each terminal daily to 18 trains.

FIGURE 5
Alternative 1A - New Bedford and Fall River via Attleboro

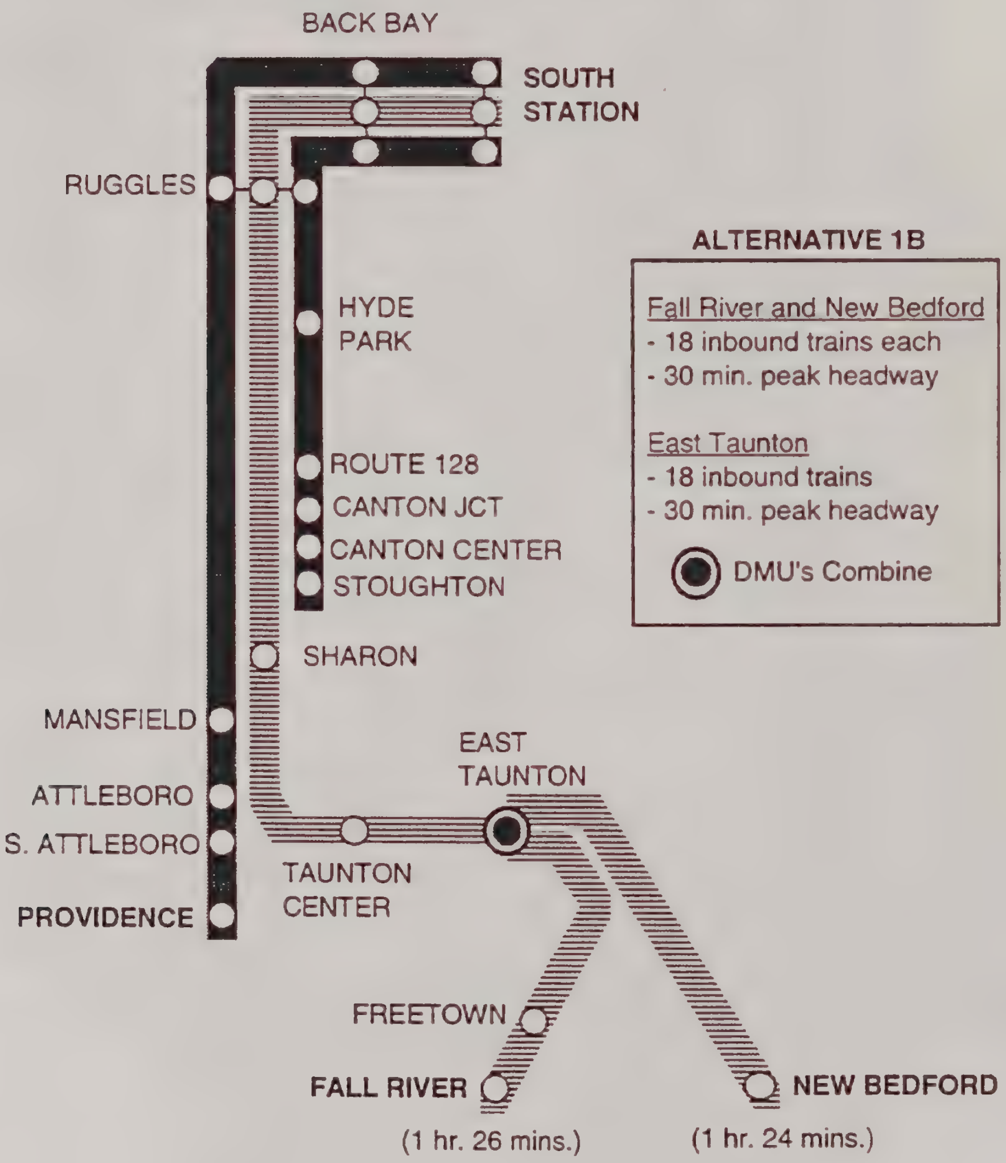


Alternative 1B: New Bedford and Fall River via the Attleboro Line Diesel Multiple Unit (DMU) Service

This alternative would follow the same route as Alternative 1A via Attleboro (see **Figure 6**). However, instead of using the standard train consists that are in now in service throughout the MBTA system (5 to 8 commuter coaches and a diesel locomotive operated in push/pull mode), diesel multiple units (DMUs) would be introduced to the system. DMUs are self-propelled rail cars that can operate in small one or two car pairs, or be coupled with additional cars to make larger consists.

FIGURE 6

Alternative 1B - New Bedford and Fall River via Attleboro - DMU Service



DMU consists from Fall River and New Bedford would meet and couple at East Taunton Station. This ability to join smaller consists into larger trainsets would have the benefit of increasing service to each terminal without increasing train traffic. North of East Taunton the service would be identical to Alternative 1A. The use of DMU cars would provide twice as much service (36 trips per day) to Fall River and New Bedford. Service would be provided from each city every 30 minutes during the peak periods.

Travel times from south of East Taunton would be longer than for Alternative 1A. To facilitate the safe operation of trains in close proximity, DMUs approaching East Taunton and planning to couple would effectively be staggered by five minutes. By alternating the lead DMU consist between Fall River and New Bedford, this five minute delay would only be experienced by passengers on every other trip. After coupling, a seven minute layover would be required to carry out brake testing. This results in a 7 to 12-minute overall added delay. The one way trip time would be approximately 1 hour and 24 minutes for New Bedford, Fall River and Freetown passengers.

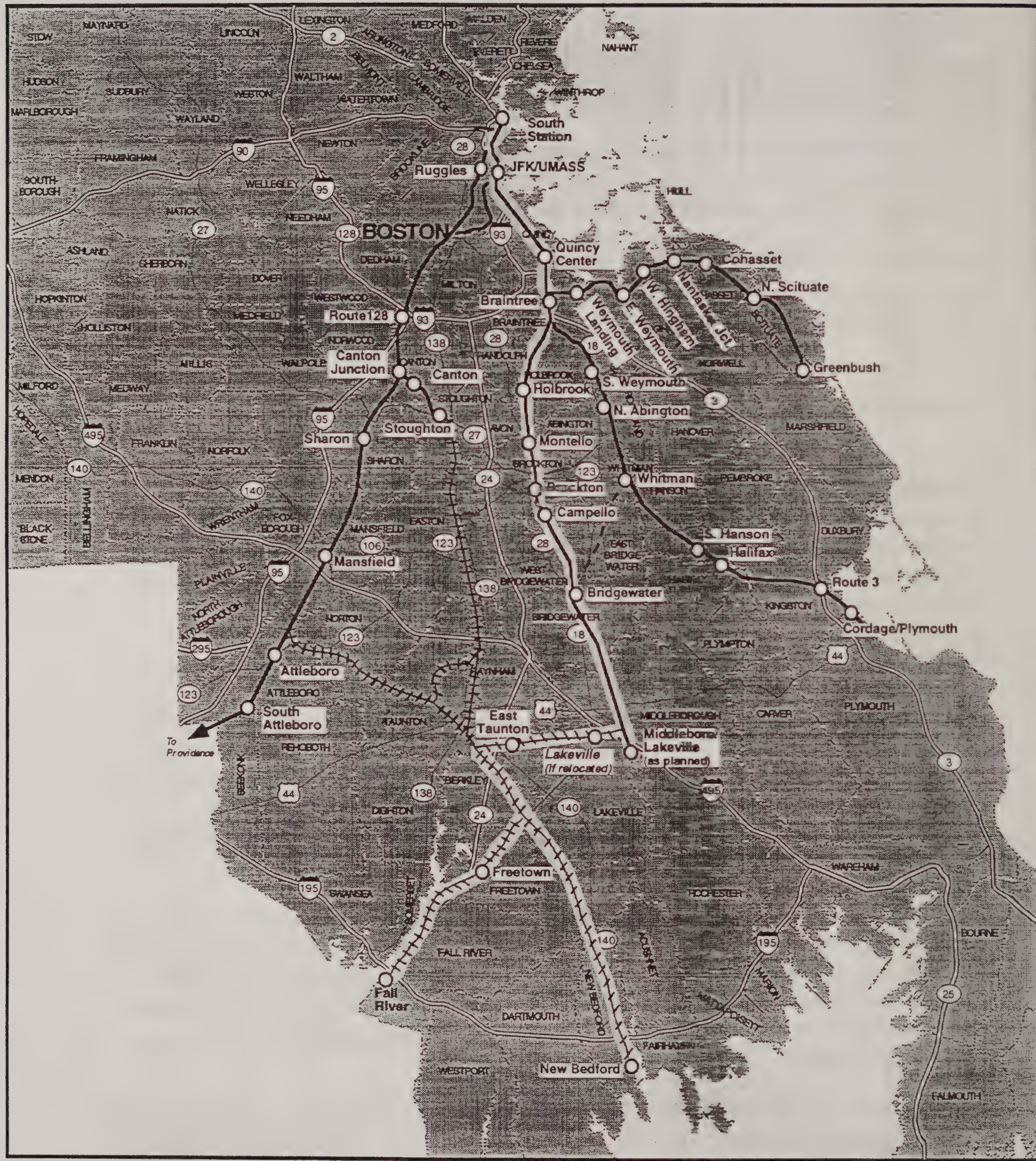
Alternative 2A: New Bedford and Fall River via the Middleborough Line Standard Consists

This alternative would be an extension of the Old Colony Middleborough Line. Service would be extended from the planned Old Colony terminus at Middleborough/Lakeville to both New Bedford and Fall River (see **Figure 7**). The service would branch from the Old Colony Line and would follow the Middleborough Secondary track to East Taunton and Cotley Junction. South of East Taunton, service would follow the same alignment as the Attleboro route.

As part of the Old Colony project, Middleborough/Lakeville Station is being constructed about one mile south of the junction of the Middleborough Secondary. This alternative assumes that this station would be retained at its present location, and requires New Bedford and Fall River trains to reverse direction and travel northbound before heading west on the Middleborough Secondary. This reverse move would add at least 10 minutes to the overall travel time, due to the longer distance travelled and the need to perform brake tests before changing direction. Relocation of the Middleborough/Lakeville terminal to avoid this time penalty is analyzed under Alternatives 2C and 2C-1.

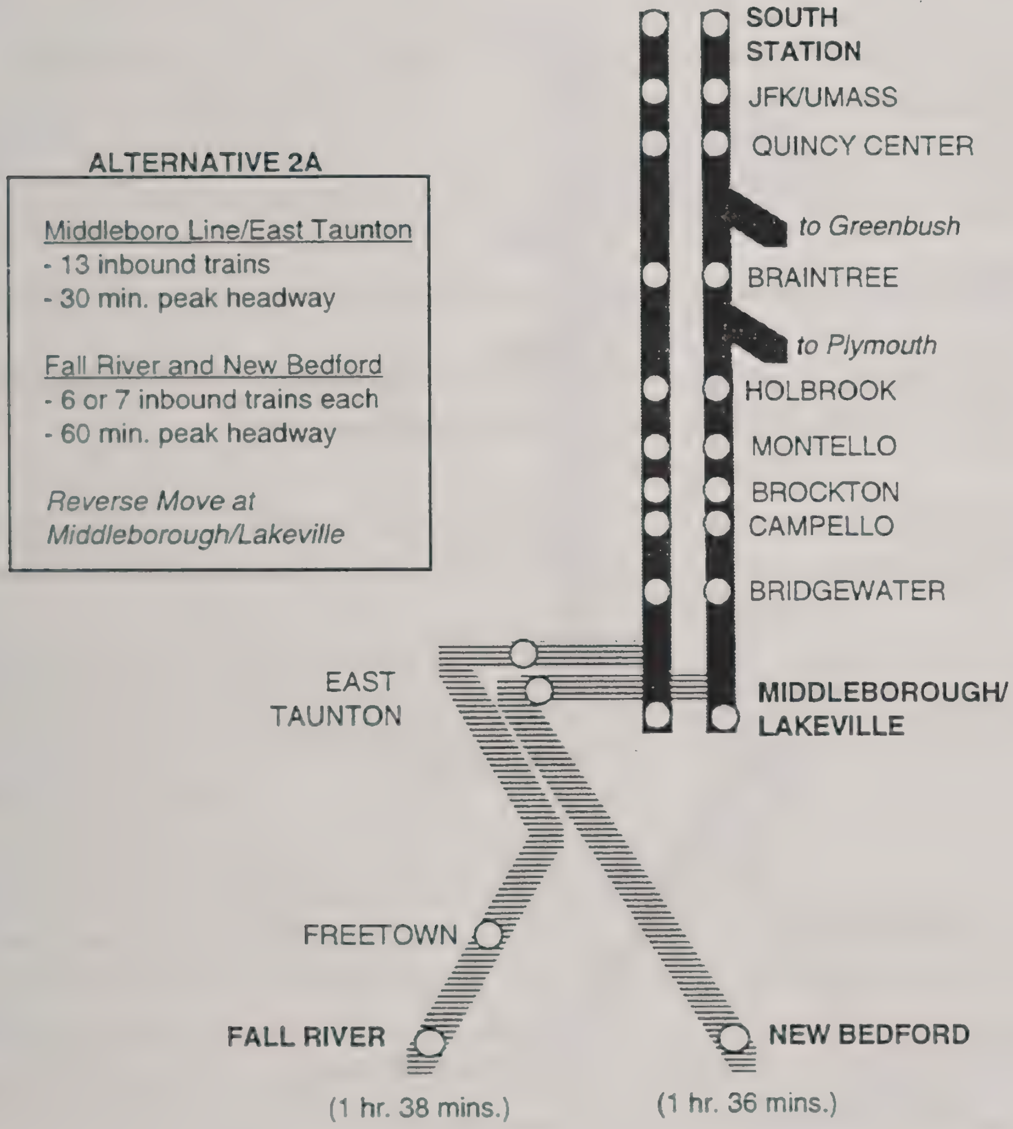
To avoid a second "reverse move", the East Taunton station would be relocated from its formerly proposed site north of Cotley Junction. Nine sites were evaluated: two along the Middleborough Secondary east of Route 24 in Taunton, two west of Route 24, one at the Silver City Galleria, and four sites south of Cotley Junction in Berkley. For the purposes of this study, the Taunton sites east of Route 24 were considered to provide the best commuter access with the least environmental impact.

Figure 7
Commuter Rail Service to New Bedford and Fall River via Middleborough
Alternatives 2A, 2B, 2C and 2C1



This alternative would operate as an extension of Old Colony service. Old Colony service from Middleborough/Lakeville would be the same as planned for September, 1997. A total of 26 trains per day would operate (13 to each city), with alternating consists departing Fall River and New Bedford every hour during peak (see **Figure 8**). All trains would service East Taunton. Five peak period trains would be operated between Middleborough/Lakeville and South Station. One reverse peak direction train would operate to provide service to Bridgewater State College and to provide significant cost savings by effectively "recycling" and making two peak period runs. Old Colony service is to South Station only; Back Bay service cannot be provided because the Old Colony line uses right-of-way through Dorchester and South Boston. Total travel time to South Station would be 1 hour and 36 minutes.

FIGURE 8
Alternative 2A- New Bedford/Fall River via Middleborough
Extension of Old Colony Service - Alternating Standard Consists

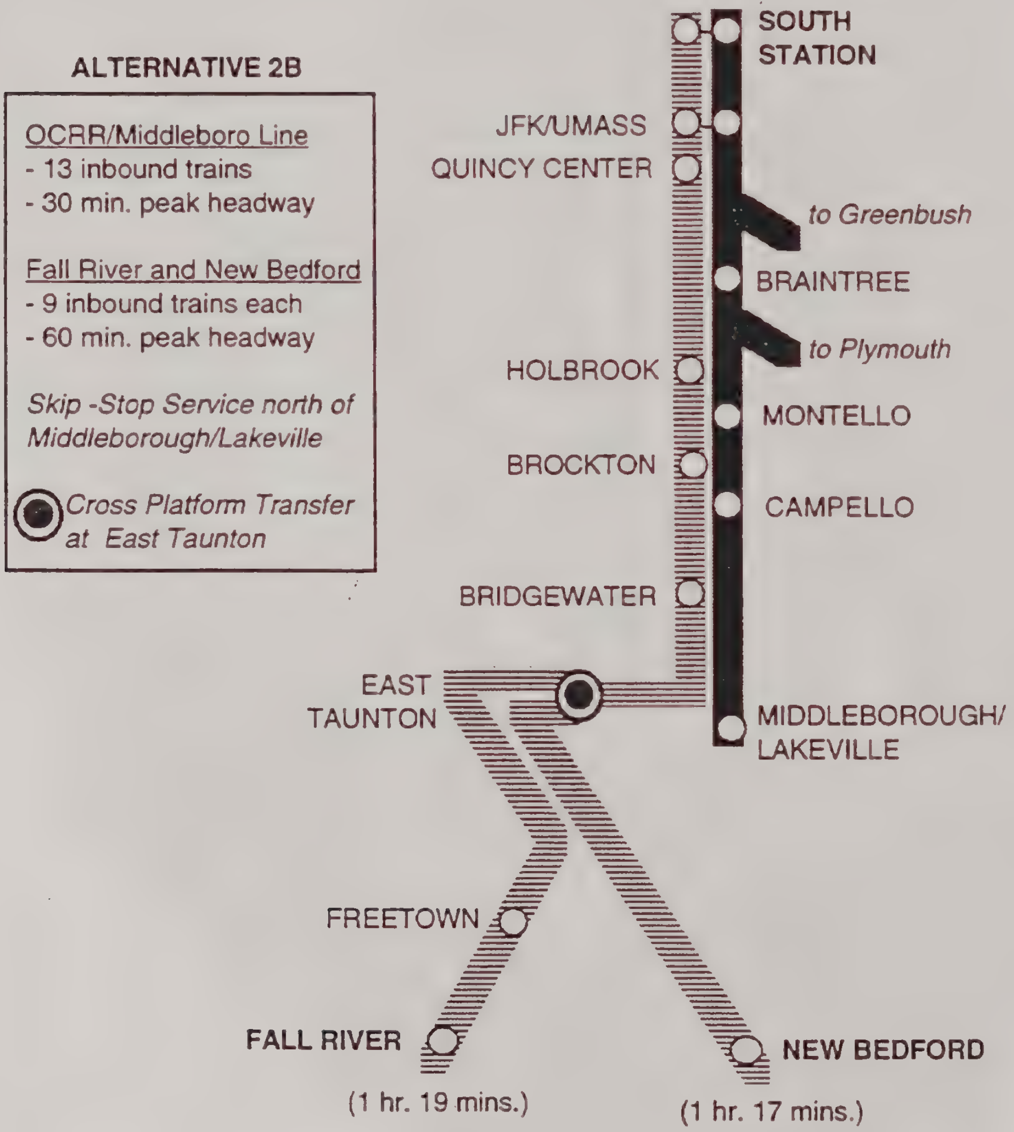


The Middleborough Secondary track is currently used by Conrail freight and Amtrak summer trains. Track reconstruction would be required to increase speeds and improve grade crossings. Small sections of new track would be built at Cotley Junction and at the Middleborough Wye, enabling trains to move off and on the Middleborough Secondary.

Alternative 2B: New Bedford and Fall River via the Middleborough Line Skip-Stop Service/Cross Platform Transfer at East Taunton

Alternative 2B was developed to test the theory that New Bedford/Fall River service could operate "in tandem" with Old Colony Middleborough service, using the same Main Line time slots to reach South Station (see **Figure 9**).

FIGURE 9
Alternative 2B - New Bedford/Fall River via Middleborough
Skip-Stop Service/Cross Platform Transfer at East Taunton



Alternative 2B would increase the number of peak period trains to New Bedford and Fall River. The Old Colony Middleborough Line would continue to operate as a separate service, with thirteen daily trains in each direction. An additional nine trains in each direction would be routed to New Bedford or Fall River.

Trains would alternately serve each terminal on an hourly basis in the peak period as described in Alternative 2A. However, a shuttle would also operate between Fall River, East Taunton and New Bedford, providing 30 minute peak period headways to each terminal. Passengers from the shuttle would make a cross-platform transfer at East Taunton, boarding the through-routed Boston-bound train originating from the other terminal. Trip time for the passengers using the shuttle service would be 5 minutes longer than if on a through train, but still shorter than if a reverse move was required at Lakeville. To facilitate the shuttle/transfer process, a second track would be constructed between Myricks and East Taunton Station.

Once on the Middleborough Line, the through-routed New Bedford/Fall River train would not stop at Middleborough/Lakeville station , but would run "skip-stop" (in tandem) with the Middleborough/Lakeville train to Boston. New Bedford/Fall River trains would stop at all outlying stations plus Bridgewater, Brockton, Holbrook/Randolph and Quincy Center and JFK/UMass. Old Colony Middleborough/Lakeville trains would stop at Lakeville, Campello, Montello, Braintree, and JFK/UMass. During off-peak, all trains would make all station stops.

The one way trip time would be approximately 1 hour and 17 minutes.

Alternative 2C: New Bedford and Fall River via the Middleborough Line Relocated Middleborough/Lakeville Station

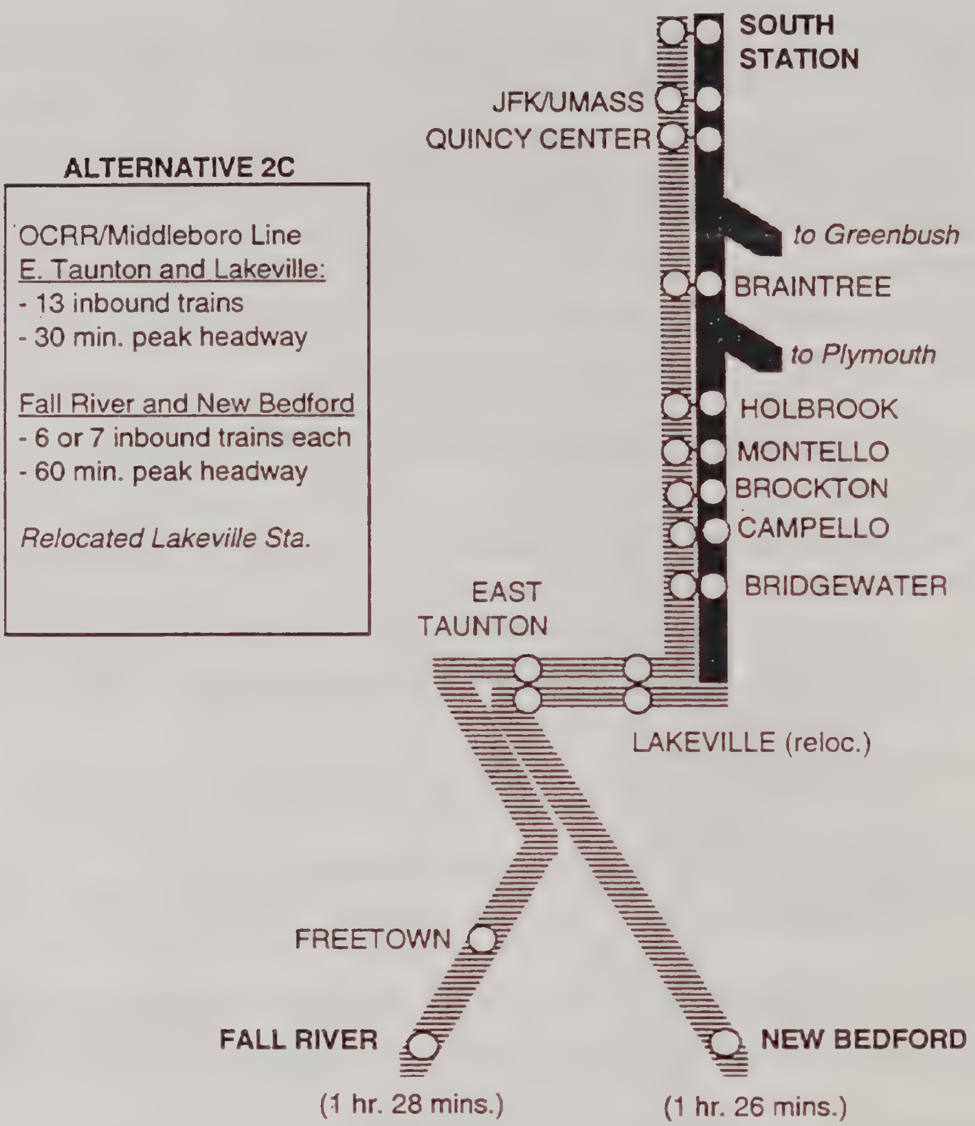
This alternative is identical to Alternative 2A except that the Middleborough/Lakeville Station is assumed to be relocated to avoid the reverse move and reduce the trip time (see **Figure 10**).

An evaluation of potential sites for relocating Lakeville station either north of, or onto, the Middleborough Secondary was performed. Out of six possible sites identified, three were discarded due to either wetland impacts, insufficient land area, poor site access or high development cost.

For the purposes of this study, a potential site in the Great Ponds Industrial Park in Lakeville was assumed for modeling purposes. The site is located on Middleborough Secondary track and is accessible from Routes 79 and 18. The site has no significant environmental constraints, although site access would be more difficult for commuters originating in Middleborough. A second potential site was identified north of downtown Middleborough, although accessibility would be more difficult for Lakeville residents. The existing Conrail Yards are also considered to be a potential site, yet relocation of Conrail operations would make this the most costly option.

FIGURE 10

Alternative 2C - New Bedford/Fall River via Middleborough
Relocated Lakeville Station/Alternating Consists

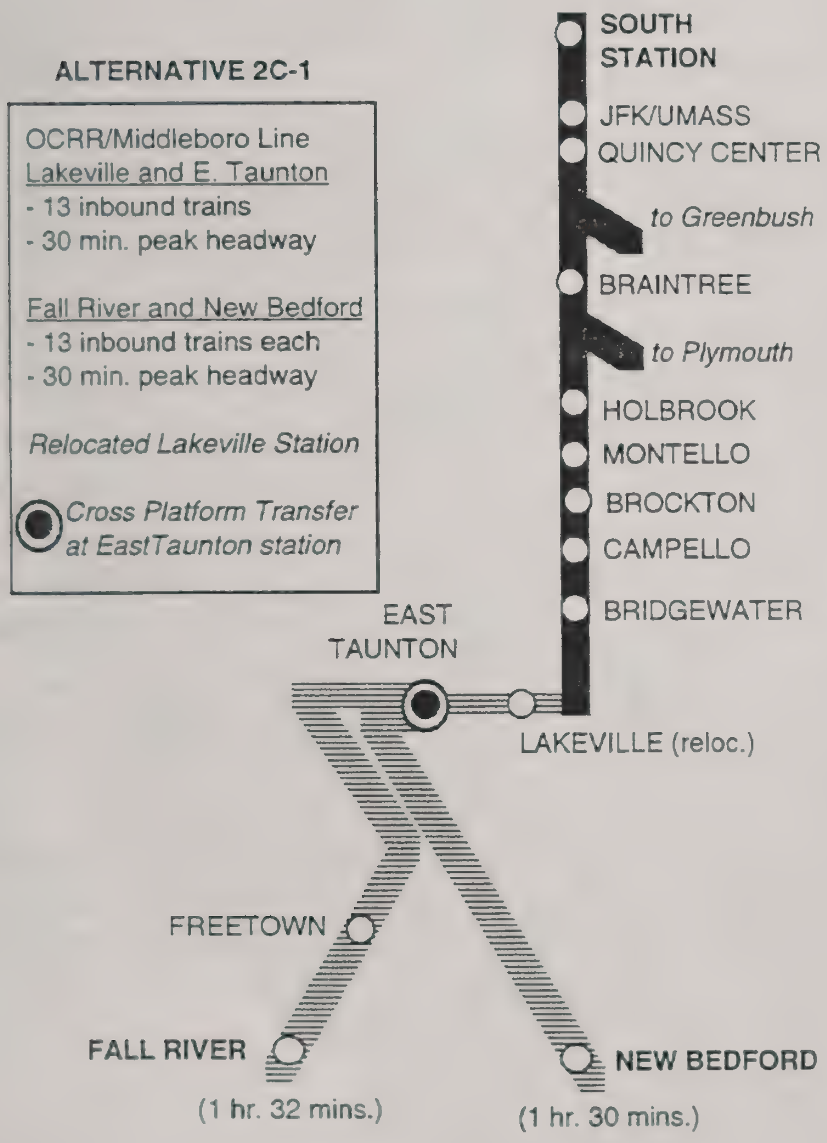


The relocated Lakeville station and the new East Taunton station would be served by 26 trains a day. Fall River and New Bedford would each be served by 13 trains daily. With the elimination of a reverse move, the one way trip time would be about 1 hour and 26 minutes.

Alternative 2C-1: New Bedford and Fall River via the Middleborough Line New Lakeville Station, Cross Platform Transfer in East Taunton

This alternative is similar to Alternative 2C, however it increases service frequency by adding a shuttle train between terminals and East Taunton station. Peak period trains would alternately operate as through trains to Fall River and New Bedford. An opposing shuttle service would bring passengers to East Taunton to make a cross-platform transfer to the Boston-bound through train (see **Figure 11**).

FIGURE 11
Alternative 2C1 - New Bedford/Fall River via Middleborough Relocated Lakeville Station/Cross Platform Transfer



The one-way travel time would be 1 hour 30 minutes, with passengers using the shuttle service experiencing a 5 minute time penalty. There would be 26 trains each weekday to all New Bedford, Fall River and Old Colony stations.

Alternative 3A: New Bedford and Fall River via the Stoughton Line Standard Consists

This alternative would involve an extension of the current Stoughton branch about 46 miles to serve both New Bedford and Fall River (see **Figure 12**). The Stoughton Branch would extend through Weir Junction serving stations in North Easton, Raynham and Taunton. It would then merge onto the Attleboro Secondary where East Taunton station would be located, travel through Cotley Junction, then diverge at Myricks to Fall River and New Bedford.

This alternative differs from the 1995 Feasibility Study in that Taunton Center and its 10 grade crossings are bypassed via Weir Junction instead of Whittendon Junction. A Dean Street station would be constructed in place of Taunton Center.

The railroad right-of-way between Stoughton and Taunton was taken out of service in 1959 and formally abandoned in 1966. Complete track and roadbed reconstruction to meet current MBTA standards would be required for use of this section of the line. Grade separation of the right-of-way would be required at Route 138. South of Cotley Junction, complete rebuilding of the New Bedford and Newport Secondary Tracks would be required as for all alternatives.

Trains would stop at Freetown (Fall River service only), East Taunton, Dean Street, Raynham and North Easton, then run express to Ruggles (see **Figure 13**). The existing Stoughton service would be extended to North Easton and would operate as local service stopping at Stoughton, Canton Junction, Route 128, Hyde Park, and Ruggles. All Stoughton line stations would receive the same level of service as today. This operating plan represents a high level of service in that New Bedford/ Fall River passengers could receive express service from North Easton. Consolidation of New Bedford, Fall River and local Stoughton service would reduce the overall operations costs of this alternative.

New Bedford and Fall River would be served by 17 trains per day. This is somewhat reduced from the 22 trains considered in the 1995 study. Total travel time to South Station would be 1 hour and 13 minutes. Service from both cities would be provided every 60 minutes in the peak periods.

Figure 12
Commuter Rail Service to New Bedford and Fall River via Stoughton
Alternatives 3A and 3B

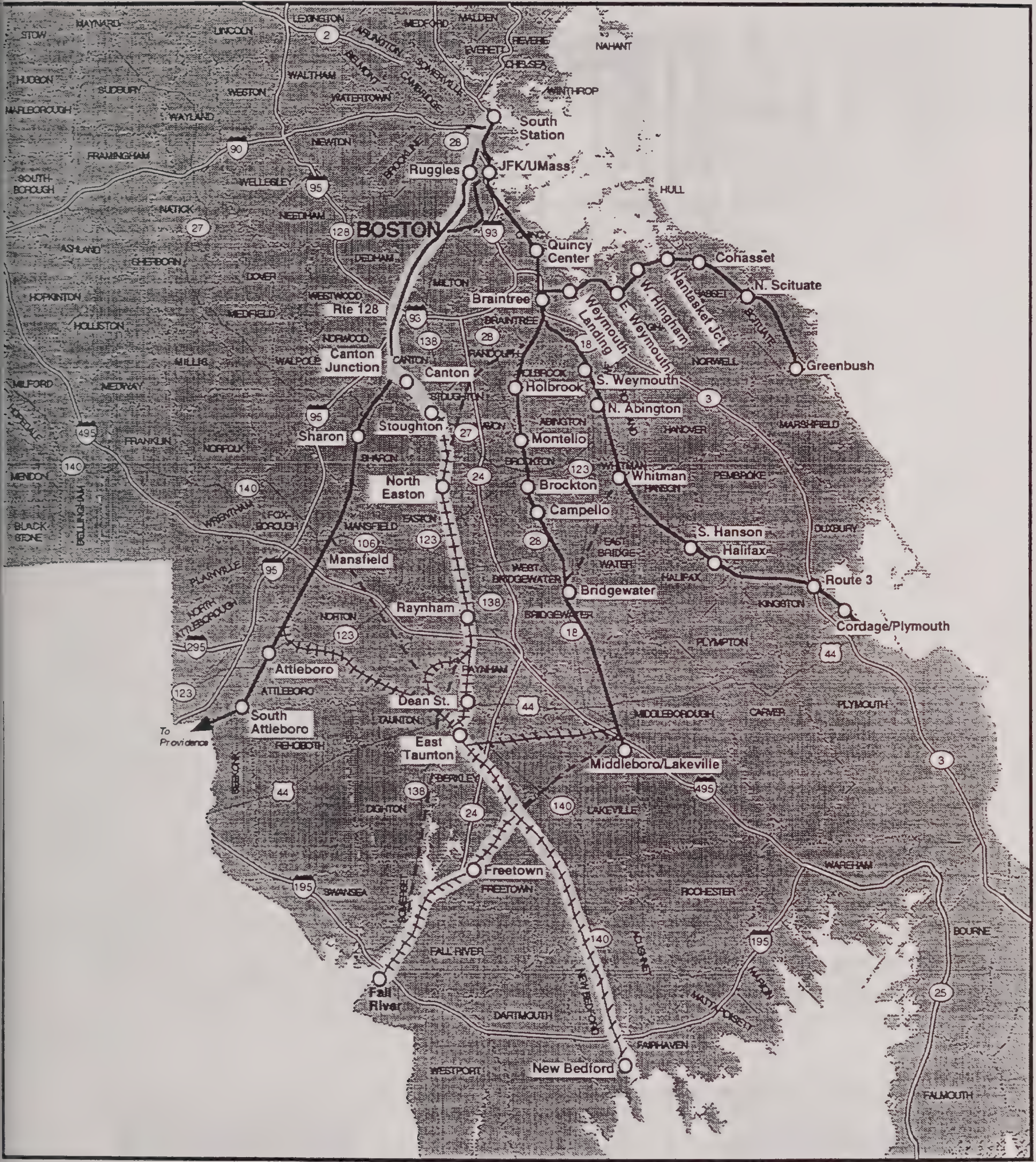
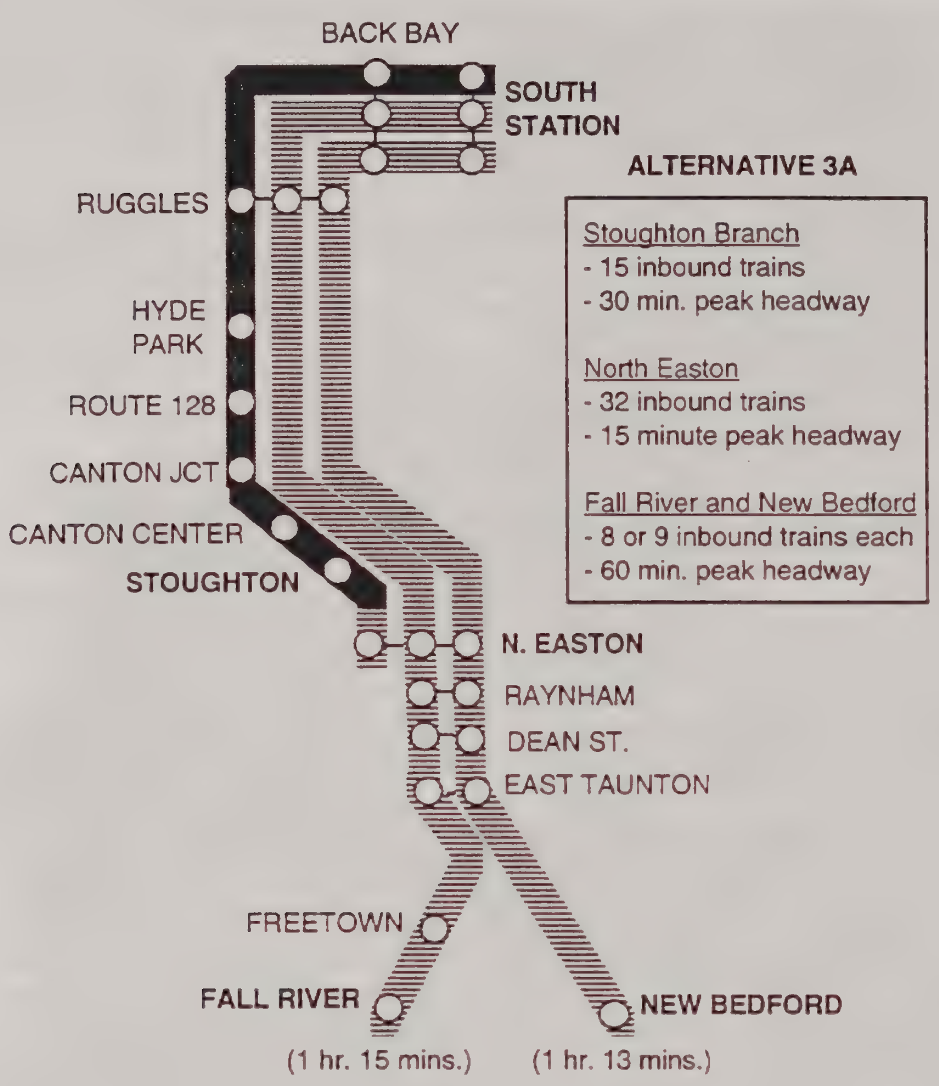


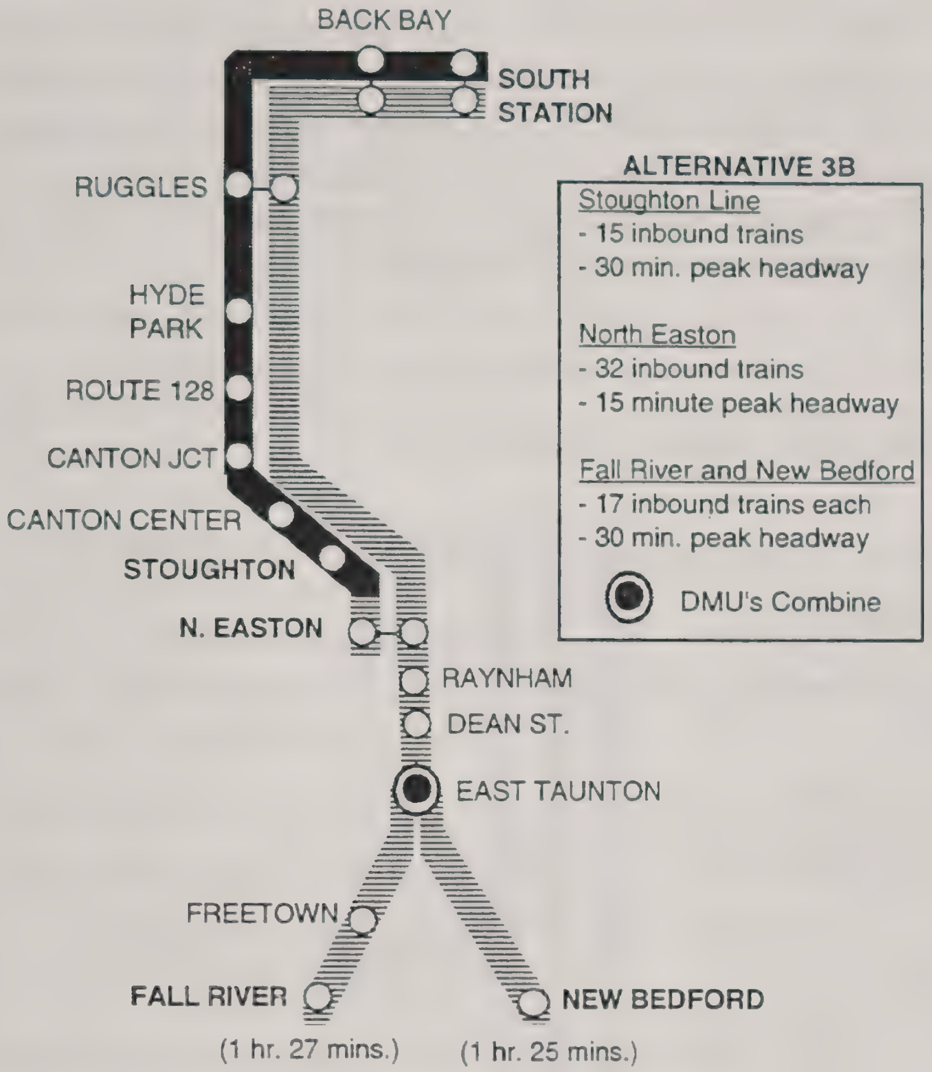
FIGURE 13
Alternative 3A - New Bedford and Fall River to South Station via Stoughton
Standard Consists



Alternative 3B: New Bedford and Fall River via the Stoughton Line DMU Service

This alternative is similar to Alternative 3A, but New Bedford and Fall River services would be operated using diesel multiple units (DMUs) which would split and join at East Taunton to serve both New Bedford and Fall River. The DMU consists would stop at all stations and run express between North Easton and Ruggles. The North Easton local would stop at Stoughton, Canton Center, Canton Junction, Route 128, Hyde Park and Ruggles (see Figure 14)

FIGURE 14
Alternative 3B - New Bedford and Fall River to South Station via Stoughton DMU Service



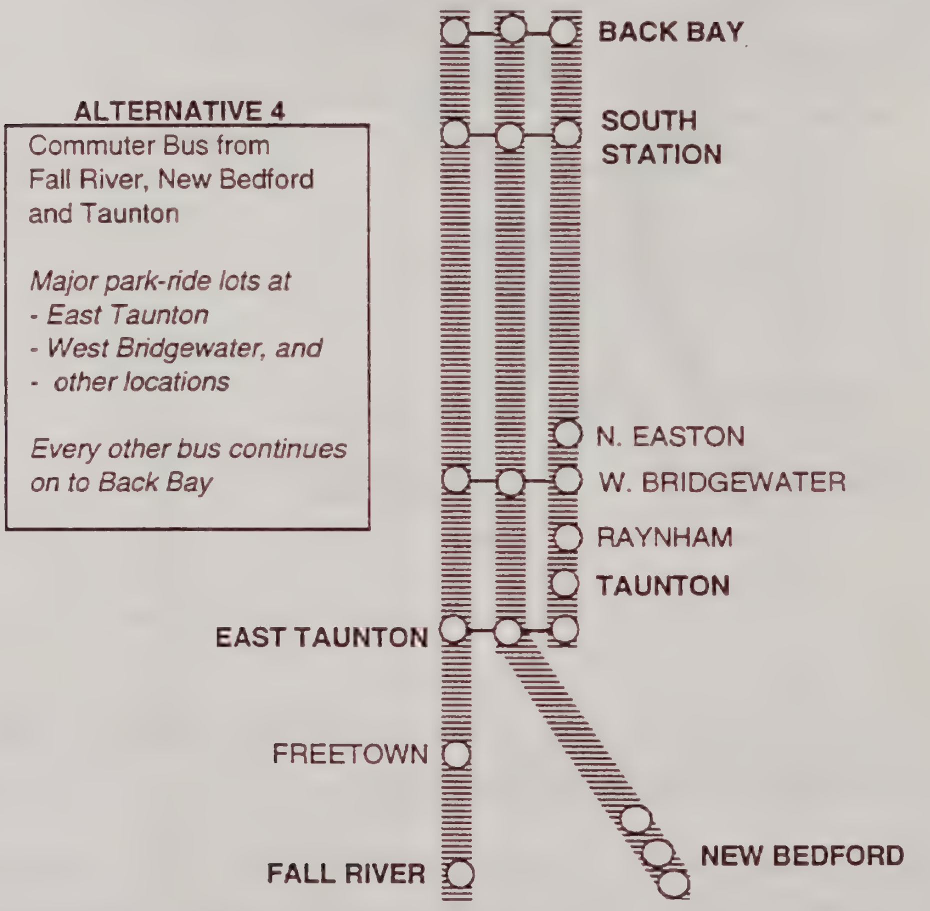
New Bedford and Fall River would be served by 34 trains per day. Service from both cities would be provided every 30 minutes in the peak periods.

Travel times from south of East Taunton would be longer than for Alternative 3A. To facilitate the safe operation of trains in close proximity, DMUs approaching East Taunton and planning to couple would effectively be staggered by five minutes. By alternating the lead DMU consist between Fall River and New Bedford, this five minute delay would only be experienced by passengers on every other trip. After coupling, a seven minute layover would be required to carry out brake testing. This results in a 7 to 12-minute overall added delay to service for New Bedford and Fall River passengers. The one way trip time would be approximately 1 hour and 25 minutes.

Alternative 4: Enhanced Commuter Bus

This alternative is designed to enhance the attractiveness of existing commuter bus service, assuming no rail extension is built. It includes operational and capital improvements to the existing bus routes between Taunton, Fall River, New Bedford and Boston. Enhancements vary by route, but include frequency improvements, better distribution and provision of park-and-ride lots. Services would be slightly modified in terms of their routing so that they have similar stopping patterns as the rail alternatives (see **Figure 15**). No improvements were considered for the existing Middleborough to Boston bus service due to the planned implementation of commuter rail service along the Old Colony Line in 1997.

FIGURE 15
Alternative 4 - Enhanced Commuter Bus Service



Bus service from Fall River would be increased from its current 25 minute headways to 15 minute headways. This service would run express to Boston with one additional stop at Freetown. The frequency of Taunton and New Bedford bus services would remain unchanged.

The Taunton service would have two stops in Taunton, one stop in Raynham and one stop in North Easton. The service from downtown New Bedford would make three stops in New Bedford, one south of Route 6, one north of Route 6, one north of I-195, as well as a Taunton stop at Routes 24/140.

All routes would service a park-and-ride facility at Routes 24/106 in West Bridgewater. Additional park-and-ride lots would be constructed where such facilities are not currently available and where the deficit would detract from potential ridership. As suggested by the Southeastern Regional Planning and Economic Development District (SERPEDD), the construction of park-and-ride lots directly off highway facilities would offer greater travel time savings for bus passengers. Buses would access these restricted facilities much like existing highway rest areas, with commuter access from the local road system. Access to commuter lots would be from local roads. These facilities would need to be constructed in cooperation with the Mass Highway Department.

To handle the additional number of buses resulting from this alternative some new terminal capacity at South Station must be provided. Also, to help reduce South Station layover constraints, every other arriving bus would continue onto Back Bay Station. The station/layover capacity at Back Bay requires additional evaluation. Identification of a remote layover facility in the downtown area would help minimize operations costs.

It was assumed that all buses would use the new HOV lane on the Southeast Expressway/I-93 for a 10 minute travel time savings. It was also assumed free transfers could be made from the buses to the MBTA transit system in order to provide better downtown distribution. Bus fares were assumed to be comparable with commuter rail fares.

It has been suggested that the construction of a second HOV facility on Route 24 south of I-93/Route 128 would facilitate commuter bus operations. The construction of a fourth travel lane on Route 128 would alleviate much of the congestion at the present Route 24/I-93 merge. This fourth lane is a base assumption in the evaluation of all future year alternatives.

Other Alternatives Considered

Service via Attleboro Station would avoid the need for a bypass track, but would necessitate a reverse move on the Northeast Corridor. This would create significant operational constraints for both the MBTA and Amtrak and would require that New Bedford/Fall River service levels be substantially reduced.

Two additional Middleborough line options were dismissed early in the process. The first would involve shuttling Old Colony passengers between Middleborough/Lakeville and Bridgewater. This would eliminate the need for New Bedford/Fall River passengers to make a reverse move at Middleborough/Lakeville. However, this was considered contrary to the base assumption that

Old Colony service levels and service quality should be maintained at levels equivalent to that planned today.

A second method of avoiding the reverse move at Middleborough/Lakeville would involve DMU technology. New Bedford/Fall River DMUs could couple together at East Taunton, then travel to Bridgewater to coupled with DMUs originating in Lakeville. This option was dismissed due to capacity constraints in carrying all New Bedford, Fall River and Old Colony passengers on one train and due to the time penalties involved with coupling twice (almost 20 minutes for some passengers).

III. RIDERSHIP FORECASTS

The travel demand forecasting for this Expanded Alternatives Analysis was performed by the Central Transportation Planning Staff (CTPS). The procedures used are based on the traditional four-step process using trip generation, trip distribution, mode choice and trip assignment. This process estimates average daily transit ridership, primarily on the basis of forecasts of population and employment, projected highway travel conditions (including downtown parking costs) and projected transit service to be provided. A more detailed description of the process and assumptions was included in the 1995 Feasibility Study.

The model is based entirely on new data obtained from a Home Interview Survey conducted in 1991. Population and employment inputs to the demand forecasting process were obtained from the Southeastern Regional Planning and Economic Development District (SRPEDD) and the Metropolitan Area Planning Council (MAPC). Network development and travel time estimation were performed using the MINUTP modeling package.

The market for the new rail service is composed primarily of work trips to downtown Boston as opposed to non-work trips or work trips contained entirely within the defined market area. Recent commuter rail surveys conducted by CTPS indicate that over 90 percent of all commuter rail trips are works trips destined to downtown Boston and East Cambridge.

As demonstrated in previous feasibility studies and shown in **Table 1**, the North Easton and East Taunton stations would attract the highest number of boardings. This reflects the large number of Boston bound work trips originating in North Easton and the good highway access attributed to the location of East Taunton station near the interchange of Routes 24/140.

Ridership in East Taunton is highest under the two alternatives using DMUs (1B and 3B). This reflects the fact that many Fall River, New Bedford, and Freetown commuters would find it more convenient to drive to East Taunton to avoid the 7 to 12 minute delay associated with DMU coupling.

Roughly equal numbers of riders would board at the Fall River and New Bedford terminal each day. The Freetown and Taunton Center stations would attract more moderate ridership. The Dean Street station avoids many of the grade crossing and community impacts identified by local Taunton officials, but would attract slightly less riders than a Taunton Center station.

Table 2 presents the projected bus boardings for each alternative. For each of the rail alternatives, commuter bus service would remain as existing.

TABLE 1
Rail Boardings By Station - Year 2010
(Inbound Person Trips)

Station of Origin	1A	1B	2A	2B	2C	2C-1	3A	3B
	Alternatives							
Fall River	650	370	350	490	375	480	620	360
Freetown	475	250	165	275	175	270	430	240
New Bedford	700	400	390	585	415	570	600	380
East Taunton	860	1,450	415	695	445	710	875	1,100
Taunton Center	545	500						
Dean Street							400	400
Raynham							300	300
North Easton							1,100	1,110
Total Rail Boardings	3,230	2,970	1,320	2,045	1,410	2,030	4,325	3,890

TABLE 2
Bus Boardings By Station - Year 2010
(Inbound Person Trips)

Stations	1A	1B	2A	2B	2C	2C-1	3A	3B	4
	Alternatives								
Taunton	135	150	400	395	400	405	75	150	300
East Taunton									600
Raynham	55	55	55	60	55	60			250
West Bridgewater									115
Easton									660
New Bedford	155	180	330	280	335	285	50	210	775
Fall River	45	15	325	260	300	265	35	110	500
Freetown									300
Total Bus Boardings	390	400	1105	995	1,090	1,015	160	470	3,500

*Combined rail and bus boardings are shown in **Table 3** on the following page.*

Under all commuter rail alternatives, bus boardings would be lower than the 1,450 daily passengers predicted for the year 2010 if no rail extensions were constructed. This is particularly true for the Attleboro and Stoughton alternatives which offer more competitive travel times to Boston. **Table 3** presents a summary of ridership, with combined bus and rail boardings for each alternative.

TABLE 3

Year 2010 Ridership - Rail and Bus Boardings Combined

Alt. No.	Description	Train Boardings[1]	Bus Boardings[2]	Total Ridership	**New Transit Riders[3]**
-	No Build	-	1,450	1,450	-
1A	NB/FR via Attleboro	3,230	390	3,620	**2,180**
1B	NB/FR via Attleboro - DMU Service	2,970	400	3,370	**1,920**
2A	NB/FR via Middleborough	1,320	1,110	2,430	**995**
2B	NB/FR via Middleborough - "Skip Stop"	2,045	995	3,040	**1,615**
2C	NB/FR via Middleborough - Relocated Lakeville Station	1,410	1,090	2,500	**1,070**
2C-1	NB/FR via Middleborough - Shuttle, Cross Platform Transfer	2,030	1,015	3,045	**1,600**
3A	NB/FR via Stoughton	4,325	160	4,485	**3,040**
3B	NB/FR via Stoughton DMU Service	3,890	470	4,360	**2,915**
4	Enhanced Commuter Bus	-	3,500	3,500	**1,790**

[1] Total daily inbound boardings at all new stations on the extension

[2] Total daily inbound boardings from the study area

[3] Total inbound trips diverted from the automobile mode

Alternative 3A, serving both Fall River and New Bedford via an extension of the Stoughton Branch, has the highest ridership with 4,325 daily inbound train boardings. In terms of diverting commuters from the automobile and achieving air quality benefits, this alternative would also be the best. This alternative provides service to the two stations with the highest ridership: East Taunton and North Easton stations.

Alternative 1A, via the Attleboro bypass, has slightly lower train boardings of 3,230. While level of service and travel times are marginally better than on a Stoughton extension, this alignment does not serve the highly attractive North Easton station and thus attracts lower ridership.

DMU alternatives along either the Stoughton or Attleboro route offer twice as much service to Fall River and New Bedford, but ridership is 6 to 10 percent lower. This is due to current federal regulations which add a 7 to 12 minute time penalty for brake tests during DMU coupling.

Alternative 4 - Enhanced Commuter Bus, would attract the second largest ridership, increasing bus ridership by more than 100 percent. More than 3,500 passengers would use enhanced New Bedford, Fall River and Taunton bus service due to lower fares, free transfers to the MBTA rapid transit system (i.e. acceptance of MBTA monthly passes) and increased commuter parking availability. An estimated 1,790 of these commuters would be diverted from automobiles.

Middleborough line Alternatives 2A and 2C have the lowest ridership potential. Even Alternatives 2B and 2C-1, which have service levels and travel times which are more competitive with the Attleboro and Stoughton routes, attract only 2,045 inbound train riders. The relocation of Lakeville station would reduce travel time by about 10 minutes, but would have little impact on ridership as demonstrated by the minimal difference between Alternatives 2A and 2C.

It should also be noted that the use of supplemental shuttle service to increase ridership on the Middleborough line alternatives (2B and 2C-1) could also be implemented for the Stoughton and Attleboro line alternatives. This would further increase ridership levels on these routes and amplify the relative benefits of these routes as compared to the Middleborough line options.

For comparison purposes, the following ridership statistics are provided from 1995 ridership counts on other MBTA commuter rail lines. Only Alternatives 1A or 3A, with service via Attleboro or Stoughton, would attract ridership at levels comparable to other MBTA lines.

Existing Commuter Rail Line	1995 Daily Inbound Boardings
Attleboro/Stoughton	11,750
Rockport/Ipswich	6,420
Franklin	6,150
Framingham	5,430
Haverhill	4,060
Lowell	4,030
Fitchburg	3,850
Needham	3,500
Fairmount/Dorchester (branch)	1,410

IV. OPERATIONAL ISSUES

A. GENERAL OPERATIONAL ISSUES

Operational simulations were developed along each of the three alternative alignments to determine the feasibility and impact of Fall River/New Bedford service in the year 2010. These simulations were developed utilizing a sophisticated computerized simulation tool called RAILSIM. These simulations helped to develop travel times and service schedules for each alternative (see **Table 4**). The results were then used to identify and evaluate any operating issues as described further below. Bus travel times were generated from the regional model.

TABLE 4
Rail and Bus Alternative Trip Times

Alt. No.	Description	Total Route Miles[1]	# of Stations (total/new)	# of Pk. Period Trains[2]	Peak Trip Time[3] (hr:min)	Trains per day[4]
1A	NB/FR via Attleboro	61/58	8/5	3	1:12	18/18
1B	NB/FR via Attleboro-DMU Service	61/58	8/5	5	1:24[4]	36/36
2A	NB/FR via Middleborough	61/58	12/4	2 or 3	1:36	13/13
2B	NB/FR via Middleborough - Skip-Stop, Shuttle/Transfer	61/58	9/4	5	1:17[4]	18/18
2C	NB/FR via New Lakeville Station	59/56	12/5	2 or 3	1:25	13/13
2C-1	NB/FR via New Lakeville Station, Shuttle/Transfer	59/56	13/5	5	1:30[4]	26/26
3A	NB/FR via Stoughton	54/51	9/7	3	1:13	17/17
3B	NB/FR via Stoughton-DMU Service	54/51	9/7	5	1:25[4]	34/34
4	Enhanced Commuter Bus	varies	10/3	n/a	1:30	n/a

[1] Distances from New Bedford / Fall River to Boston

[2] Number of peak period trains to each terminal

[3] Times are for New Bedford. Add about two minutes for the Fall River trip.

[4] Total daily (inbound + outbound) trains to New Bedford/Fall River.

[5] Time includes transfer or DMU coupling at East Taunton station; travel on through trains is 5 minutes faster.

Maximum train speeds were generally assumed to be 70 mph along all lines, with the exception of the Northeast Corridor on which future speeds were assumed to be 100 mph. Slower speeds of 30 mph were maintained along sections in Taunton to account for the frequent sharp curvatures and numerous grade crossings. A dwell time of one minute was assumed for all station stops.

Layover Facilities

New layover facilities would be required in New Bedford and Fall River. The Middleborough layover facility being constructed as part of the Old Colony project would definitively need to be utilized only under Alternative 2B. If all Middleborough service were extended beyond this point, the need to retain some layover capability at this midpoint would need to be further evaluated.

Cross Platform Transfers

To overcome Main Line capacity limitations, service frequency to New Bedford and Fall River could be improved by operating shuttle trains between the terminals and East Taunton. This type of operation was incorporated into Alternatives 2B and 2C1. This type of service could also be used to boost service levels and ridership on the Attleboro and Stoughton options as well.

A shuttle train and a larger, through-routed train would alternately serve each city. Every other train leaving New Bedford would be a shuttle. In theory, both the shuttle and the through-routed train departing NB/FR would be scheduled to arrive at East Taunton simultaneously. This requires that the right-of-way between Myricks and East Taunton Station be double tracked. The two trains would pull up to an island type platform and patrons would cross from one train to another to continue the inbound trip. Shuttle trains can be either DMUs or a locomotive pulled consist. A comparative evaluation of the relative costs for operating DMU or traditional equipment is performed later in this report for the purposes of identifying operating costs.

B. NEC CONSTRAINTS

The Northeast Corridor (NEC) Improvement Project consists of a major upgrade of Amtrak's Shore Line which operates between Boston and New York. The project involves electrification of the line to facilitate three-hour trip times between Boston and New York. Amtrak plans to run faster and more frequent service on the line (34 trains daily in the year 2010 as opposed to the current 16). This increase will limit the number of additional trains that the MBTA can operate along this corridor.

As part of this expanded alternatives analysis, operational simulations were developed for year 2010 service levels to test the number of trains that could enter the Northeast Corridor from either the Attleboro bypass or the existing Stoughton Branch. The simulations determined that up to 36 trains per day could access the corridor in the Attleboro area. The simulation determined that the number of additional trains that could access the corridor from the existing Stoughton Branch was 34 per day. This number is slightly less than via Attleboro because of the scheduling of service on the Northeast Corridor.

This identified capacity for 34 to 36 additional trains entering the Northeast Corridor from the Attleboro or Stoughton alignments is somewhat reduced from the 44 trains that were assumed in the 1995 Feasibility Study.

Simulation results also showed that, to accommodate additional traffic without disrupting Amtrak or MBTA Shore Line services, the proposed Attleboro bypass would need to be double-tracked. This would facilitate the passing of trains moving in opposite directions and to quickly move trains on and off of the Northeast corridor.

C. MIDDLEBOROUGH LINE OPERATIONAL ISSUES

Old Colony Capacity Constraints

Old Colony system constraints are primarily a result of capacity limitations north of Braintree on the Main Line. The three Old Colony lines from Middleborough, Plymouth and Greenbush merge in Braintree and proceed north to South Station on a shared 9.8 mile section of single track known as the Main Line. The limited capacity of this Main Line segment constrains operations on the entire Old Colony system.

The Main Line must accommodate 76 trains per day from the Plymouth, Greenbush and Middleborough branches. Operations will be particularly constrained during the peak periods when each Old Colony branch will be served by 5 trains in the peak direction. To minimize equipment requirements, the first AM peak-period train arriving at South Station from each line is scheduled to run a reverse peak trip to also serve as the fifth inbound train. Thus, morning peak operations on the Main Line will consist of 15 inbound trains (five from each line) and 3 outbound trains (one to each line). The PM peak will operate in a similar manner. Two platforms at South Station will be dedicated to Old Colony trains. The platforms selected (track #11 and #12) provide for direct movement onto the Old Colony tracks and help the efficient movement of trains.

The 1995 Feasibility Study evaluated Middleborough line options that serve only one terminal, either New Bedford or Fall River. The assumption was that no additional service could be added to the Main Line. This was designed to offer a high level of service to one terminal rather than infrequent service to both. As part of this current analysis, four new Middleborough alternatives were developed.

Alternatives 2A, 2C and 2C-1 would operate as extensions of Old Colony service. No simulations were performed for these alternatives because there would *theoretically* be no additional trainsets added to the Main Line north of Braintree. (This is *theoretical* because some additional trainsets would likely need to operate to make up for the long distances of this extended service and to maintain Old Colony schedules.) However, there are two issues related to the operation of these alternatives that would limit implementation::

1) The additional 35 miles of track incorporated into service would introduce increased delay minutes throughout the entire Old Colony system. This factor is discussed in more detail below.

2) The extended trains would not have the capacity to accept both New Bedford/Fall River and Old Colony Middleborough line passengers. The maximum capacity of MBTA trains, once locomotive power is overhauled and upgraded, will be 1,550 passengers. In the year 2000, the Middleborough line is forecast to carry 1,321 passengers on the peak train. Alternatives 2A and 2C are projected to carry about 447 additional riders on the peak train. Together, this ridership would be 218 passengers or 14 percent over capacity.

   Capacity issues would be more severe under Alternative 2C-1, where an additional 657 riders would put Middleborough line service *27 percent over MBTA service standards for passenger loading.*

Impact of Additional Service

Alternative 2B was developed to test the theory that additional trains from New Bedford/Fall River service could be operate "in tandem" with Old Colony Middleborough service. A simulation was performed in an attempt to schedule these trains in "fleets" using the same Main Line time slots to reach South Station. This approach would increase the number of trains serving New Bedford and Fall River to four trains at both terminals during each peak period.

The simulation allowed for an evaluation of performance levels along the Old Colony Main Line as well as at certain station locations. Signal delay minutes were monitored to determine if the additional trains could be incorporated within the Old Colony schedules. The resulting data were used to evaluate the stability of the overall operating schedule under realistic day-to-day conditions.

As expected, the simulation demonstrated that the Main Line is the 'choke point' or location where operations are most severely constrained and where there is the least opportunity to recover from schedule delays. While it would be *theoretically feasible* to add additional trains to the Main Line, it would have a tremendous impact on Old Colony schedules and performance levels.

A single delay, which is almost unavoidable on a day to day basis, could disrupt the tightly scheduled Main Line operations and impact operations on all three branches. During the AM peak, virtually all trains travelling the Main Line to South Station would be delayed. During the PM peak, all service would be late with the exception of one train. The potential for these delays is not theoretical. On a typical weekday, roughly 42 of the 400 scheduled MBTA trains (about 10 percent) experience delays between one and five minutes. During severe snowstorms or other inclement conditions, these "minor" delays are even more frequent.

The potential impact of such delays cannot be overstated from an operational standpoint — schedule fluctuation on the Main Line segment could dead-lock service on all three Old Colony branches affecting the daily commute for more than 15,000 Old Colony passengers.

The results show that even the fixed levels of Main Line service proposed under Alternatives 2A, 2C and 2C-1 would result in an extremely fragile operating plan, by introducing an additional 35 miles of track to a system in which delay minutes cannot be tolerated.

Elimination of reverse peak service on the Old Colony line would have minimal impact on alleviating these capacity constraints. Elimination of the three scheduled reverse peak trains would *theoretically* open up slots for two additional New Bedford/Fall River trains. This action, however, would preclude the recycling of Old Colony trainsets during the peak period and add $32 million to project costs to acquire three additional trainsets.

In summary, Middleborough alternatives which simply extend service (2A, 2C and 2C-1) would not be able to accommodate both New Bedford/Fall River and Old Colony passengers without adding additional trains. The addition of New Bedford/Fall River trains to the tightly constrained Old Colony Main Line was tested under Alternative 2B. The results demonstrate that increased train traffic would have significant impacts on the level of service provided to Old Colony passengers. It would further preclude any future increase in service levels on the three Old Colony branches.

Capacity constraints along the Main Line can only be alleviated by the addition of a second track. The level of development along this corridor in Dorchester and Quincy would require numerous property takings. Construction of a second track would cost over $100 million in infrastructure, plus land acquisition and relocation costs of a significant magnitude.

Relocation of Middleborough/Lakeville Station

The Middleborough/Lakeville terminal of the Old Colony Middleborough line is presently being constructed about one mile south of the Middleborough Secondary Junction. For New Bedford/ Fall River trains to serve this station, they would have to travel one mile south of the junction; perform a brake test; then reverse direction to travel one-mile north to reach the Middleborough Secondary. The additional trip time associated with this effort is about 11 minutes.

To avoid this "reverse move', several locations were considered for relocating Middleborough/ Lakeville Station either north of the Junction or onto the Middleborough Secondary. As described in more detail under the description of Alternative 2C, three potential sites were identified. While it would be possible to move the station to one of these locations there are two additional considerations that would need to be further evaluated:

1) Relocation would require the MBTA to modify or rescind existing commitments made to the residents of Lakeville as part of the Old Colony project.

2) The Federal Transit Administration may require reimbursement of the costs for designing and constructing the current Middleborough/Lakeville terminal (up to $5 million). This reimbursement would be triggered by the MBTA's abandonment and demolition of a facility built with federal funds as identified under an existing federal grant commitment.

D. DMU OPERATIONAL AND REGULATORY ISSUES

In its simplest form, a DMU (Diesel Multiple Unit) is best described as a conventional passenger coach with a diesel engine, which allows the coach to operate without a locomotive. Modern DMUs, which are updated versions of the old "Budd" rail diesel cars used in Boston until the late 1970's, are in widespread use in both Europe and Japan. There is a growing interest in reintroducing this technology in the U.S. to take advantage of increased operational flexibility and other operational benefits provided by these trains.

DMUs possess characteristics that may make them suitable for New Bedford/Fall River service. Because they can operate in small one or two car pairs, they can much more efficiently serve a wide range of ridership volumes. They may also be coupled with additional cars to make larger consists which makes them ideally suited for branched service. This ability to join smaller consists into larger trainsets provides the ability to offer increased service on each branch without increasing train activity north of East Taunton.

As part of this expanded alternatives analysis, the MBTA's consultant prepared a technical memorandum on the cost to operate and maintain DMUs and evaluated their performance as part of several operational simulations. The conclusions of these analyses include:

- In short consists, DMUs are more efficient to operate and maintain than locomotive-hauled equipment of similar capacity. The higher costs for each individual coach limit their advantage to consists with less than 400-600 passengers.
- Better fuel economy makes DMU's more attractive as the price of fuel increases.

- While European operators routinely couple and uncouple DMUs "on the fly", current Federal Railroad Administration (FRA) safety regulations require that brake tests be performed after coupling. This adds about 7 minutes to the operating schedule.
- Also, as with any standard consist, an adequate headway must be maintained between trains operating along a track segment. For two inbound DMUs planning to couple at East Taunton, this implies that the second DMU would have to trail the first by five minutes minimum. Thus, the combination of train spacing and brake testing would result in a total delay of 12 minutes for these passengers.

As interest in the use of DMU technology increases in the United States, it is hoped that the FRA would develop special rules for DMUs to overcome some of the operating restrictions noted above. However, all simulations conducted for this expanded analysis conservatively assumed that all current regulations would apply.

E. OTHER CONSIDERATIONS

South Station Capacity

The 1995 Feasibility Study included an evaluation of the track capacity at South Station. The estimated station capacity for 2010 took into account the additional track space required for Old Colony Service, MBTA service to Worcester, increased service along the Franklin line, extension of service to New Bedford/Fall River and additional Amtrak service along the Northeast Corridor. The results showed that South Station can accommodate New Bedford/Fall River service, but will essentially be at capacity in the year 2010, particularly in the evening peak.

It is recommended that this issue, regardless of the alignment selected, be further investigated following the selection of a preferred alignment. This would be particularly important for any option that added service to the Old Colony system, because the two platforms dedicated for Old Colony trains would be unable to accommodate additional trains during the peak periods. Any additional service, as considered under Alternative 2B, would need to board passengers at alternate platform locations. The dedicated Old Colony platforms are situated to provide for direct and efficient access onto the Main Line. The need to route trains across South Station operations would increase the potential for operational delays.

Potential Service to Bourne via Middleborough

In September, 1996, the MBTA completed a feasibility study of a potential extension of Old Colony Middleborough service to Bourne and Cape Cod. This study found that such an extension would attract 1,200 inbound passengers (or 2,400 total) trips per weekday. The extension of service to Fall River and New Bedford via Middleborough would limit the feasibility of operating through service to Bourne and Cape Cod. Further analysis would need to be performed to determine if double tracking north of Braintree could accomodate both new lines.

V. ENVIRONMENTAL ASSESSMENT

A. BACKGROUND

A project of this magnitude is required to be reviewed by MEPA. In September 1995, an ENF to extend rail service via the Attleboro route was submitted to MEPA . In December 1995, the Secretary of the Executive Office of Environmental Affairs (EOEA) issued a Certificate on the proposed Attleboro Route. This Certificate required the preparation of an Environmental Impact Report for the proposed Attleboro bypass segment of the project. No additional environmental review was required for track reconstruction or stations. If a different alternative were to be pursued, additional review by MEPA would be required.

This Chapter compares the potential environmental impacts likely to occur from the rail alternatives and the bus alternative. The information presented is only intended to be a summary of potential impacts to facilitate comparison. Accordingly, this assessment only considers the alternative routes north of Cotley Junction. All alternatives are assumed to have identical environmental impacts from Cotley Junction south.

B. ENVIRONMENTAL REVIEW OF ALTERNATIVES

A series of environmental issues (i.e. wetlands, floodplains, waterways, biological resources, noise, and air quality) are presented below as part of a cursory review. Grade crossings are also discussed because of the noise and traffic issues which effect abuttors on each rail alternative. Environmental issues relating to station development were considered only when alternative station locations were investigated (as described earlier under the Description of Allernatives).

This summary focuses only on permanent impacts. Minor temporary impacts would be encountered as a result of construction activities (bridge abutment work, site access, etc.)

Wetlands, Floodplain and Waterways

Significant portions of the right-of-ways being considered are within 100 feet of wetland resource areas and receive protection under the Massachusetts Wetland Protection Act. Most actions would require the filing of a Notice of Intent (NOI) permit with local conservation commissions.

The Attleboro Route

Due to the construction of a new 2.5-mile double-tracked bypass between the Shore Line and the Attleboro Secondary, this alternative would directly affect about 5.4 acres of wetlands. Impacted resources would include relatively mature forested wetland, marsh, and shrub swamp wetlands, and potentially could affect larger areas due to changes in hydrology. The filling of wetlands would require that a variance be obtained from the Wetlands Protection Act Regulations.

This alternative would result in direct impacts to two surface water streams. The line crosses waterways at 14 locations and runs parallel to about 400 feet of a tributary to the Wading River which would require relocation or culverting. Direct impacts would result from the placement of ballast material and culverts within the watercourse channels.

The 100-year floodplain borders the right-of-way embankment base, but does not extend onto the tracks. Portions of the new track would be within riverfront areas.

The Middleborough Route
This alternative would result in the least impact to wetland and water resources primarily due to the fact that the entire alignment uses an active rail line. Construction of the Wye connector at Cotley Junction would adversely affect approximately 5,000 square feet of wetlands, but would not be likely to require issuance of a Wetlands Variance. The line crosses nine streams in culvert structures, although no impacts are expected. No construction within or adjacent to the 100 year floodplain is anticipated.

The Stoughton Route
The line passes through the 17,000 acre Hockomock Swamp ACEC (Area of Critical Environmental Concern). This is the largest freshwater wetland system in the state. It provides habitat for at least 13 rare and endangered species and has public recreational values. An ACEC is a designation established by the EOEA for especially sensitive environmental resources.

This alternative would require the construction of a 3.2 mile section of track in the Hockomock Swamp ACEC and a 1-mile section in Pine Swamp both on existing embankments. This work would be within the buffer zone, but would not alter wetlands in the ACEC.

Approximately two acres of wetlands, outside the ACEC, would be directly affected by the project. This includes locations where the former railbed is in a cut section where wetland vegetation exists due to impeded drainage. These recently-established wetlands have a disturbed substrate and vegetation, and provide lower functions and values than do older natural wetland systems. The limited functions and values should be factors that would argue in favor of the granting of a Wetlands variance.

The line also crosses 24 surface waterways, and direct impacts would occur at two streams which have cut through the abandoned rail bed and would need to be replaced with culverts. The 100-year floodplain borders the right-of-way embankment base, but does not appear to extend onto the tracks.

The right-of-way through the ACEC serves as a recreational trail and provides wildlife refuge uses. Although it was originally purchased for transportation uses prior to the designation of the ACEC, some replacement of this recreational use may need to be considered.

Wildlife and Rare Species

Wildlife habitat within the proposed powerline right-of-way in Attleboro would be reduced in area and fragmented due to the clearing of about 15 acres of land. The Stoughton alternative would result in direct loss to wildlife habitat along the abandoned trackbed and through the Hockomock Swamp ACEC and Pine Swamp. Rare fish species are present in the Taunton River, which is crossed by both the Attleboro and Stoughton routes. However, careful construction sequencing of bridge repair and mitigation should prevent adverse impacts from occurring to that species.

The Middleborough alternatives would not adversely impact wildlife or rare species due to the fact that the track is in service. New track construction at Cotley Junction and the Middleborough Wye would not affect any areas of important wildlife habitat.

Noise And Vibration

Each alternative would generate an increase in the existing ambient noise levels along the specific rail corridor. The amount of noise level increase is directly dependent on the current level of train activity in that corridor and the level of new train service proposed. In the built-up areas of Easton Center, Taunton, New Bedford and Fall River, the increase in noise levels may be a concern.

Noise and vibration impacts are generally correlated with the distance and number of residential and other land uses along the right-of-way. **Table 5** identifies and compares the number of noise receptors (residences and businesses) located within 150 feet of each right-of-way north of Cotley Junction (150 feet is generally the distance from which noise impacts would be experienced). Noise impacts are typically associated with noise from the train itself, grade crossing bells and the blowing of train whistles. Recent changes in federal regulations have introduced alternative grade crossing measures to replace the blowing of train whistles in some locations.

Based on the quantitative abutter assessment, it appears that the Middleborough Line would cause the least noise impacts to commercial and residential structures located within 150 feet of the right-of-way. The Attleboro route has the next greatest number of abuttors, with most located in the Taunton area. The Stoughton route has the greatest potential for residential impact, with land use impacts mainly in Taunton, Easton, and Stoughton.

TABLE 5

Abutters within 150 feet of the Right-of-Way: To Cotley Junction

	Attleboro		Middleborough		Stoughton	
Town	Residential	Commercial	Residential	Commercial	Residential	Commercial
Mansfield	4	0	0	0	0	0
Attleboro	0	0	0	0	0	0
Norton	13 (11)	3 (3)	0	0	0	0
Stoughton	0	0	0	0	44	63
Easton	0	0	0	0	58 (14)	33 (18)
Raynham	0	0	0	0	19 (16)	9
Taunton	121 (106)	31 (30)	9 (5)	1 (0)	52 (17)	16 (11)
Lakeville	0	0	4 (8)	2 (0)	0	0
Middleborough	0	0	20 (0)	5 (0)	0	0
Total	138 (131)	34 (33)	33 (13)	8 (0)	173 (91)	121 (101)

Number in ( ) indicates abutters who are within 150 feet of an at-grade crossing, if different from total.

Vibration impacts may also be a concern in developed areas. One area identified that may require some vibration protection is the historic area of North Easton. It is possible that some sections of track in North Easton may require a deeper ballast section than usual.

Grade Crossing Impacts

The number of at-grade crossings that would be required for each of the three alternative routes north of Cotley Junction is shown in **Table 6**. The crossings south of Cotley were discussed in the previous feasibility studies and are not a factor in selecting a preferred alternative. Crossings north of Lakeville on the Middleborough Line will be impacted by the additional service under alternative 2B. All grade crossings would be protected by automatic gates and crossing signals (bells and flashers).

Attleboro Route: Most of the Attleboro route is in use by both freight and passenger service and would involve 19 existing at-grade crossings and one new crossing.

- One new at-grade crossing would be constructed along the Attleboro bypass, although the Route 123 crossing in this area would be grade separated.
- Fifteen grade crossings are located in Taunton.
- Nine grade crossings have low traffic volumes
- Five grade crossings experience relatively high traffic volumes.

Middleborough Route: The Middleborough Secondary is an active Conrail freight line, with only five existing at-grade crossings.

- One grade crossing has low traffic volumes and is located on a residential street.
- Three grade crossings have low-moderate traffic volumes and are located on residential/industrial roadways.
- One crossing (Route 140) has high traffic volumes and is located on a commercial highway.

The Middleborough line from Braintree to Lakeville has 15 public and 6 private grade crossings.

Stoughton Route: The Stoughton route is not currently active and would require the reconstruction of 24 new at-grade crossings.

- Five crossings have low traffic volumes and are located on residential or industrial roadways.
- Eight grade crossings have low-moderate traffic volumes and are located on a combination of residential/commercial/industrial streets.
- Ten crossings have moderate traffic volumes and are located on a combination of residential/commercial/industrial streets.

The Route 138 grade crossing has high traffic volumes and will require the construction of a grade-separated railroad crossing.

TABLE 6
Summary of At-Grade Crossings: To Cotley Junction

	Attleboro	Middleborough	Stoughton
Town	No. Of Crossings	No. Of Crossings	No. Of Crossings
Attleboro	1	0	0
Norton	4	0	0
Stoughton	0	0	5
Easton	0	0	8
Raynham	0	0	6
Taunton	15	2	5
Lakeville	0	1	0
Middleborough	0	2	0
Total	20	5	24

Traffic Issues and Regional Air Quality Benefits

Traffic analysis for this study was limited to the calculation of trips diverted from automobiles to transit and a determination of savings in total vehicle miles traveled (VMT). As shown in **Table 7**, the greatest reduction in total VMT and hence the greatest benefit to air quality would be realized by the Stoughton Route (Alternative 3A). The Commuter Bus Alternative and the Attleboro Route (Alternative 1A), also have relatively high VMT savings and reductions in air pollutants. The Middleborough alternatives do not reflect high VMT savings and therefore have relatively fewer air quality benefits.

TABLE 7
Regional Air Quality Benefits

				Daily Reductions		
Alt. No.	Description	Total Transit Riders	Daily VMT[1] Savings	NOx (Kg)	CO (Kg)	VOC (Kg)
1A	NB/FR via Attleboro	3,230	169,290	1185.7	169.1	96.0
1B	NB/FR via Attleboro - DMU Service	2,970	137,470	962.8	137.3	77.9
2A	NB/FR via Middleborough	1,320	72,110	72.1	505.1	40.9
2B	NB/FR via Middleborough - Skip Stop, Shuttle/Transfer	1,320	99,765	99.7	698.8	56.6
2C	NB/FR via Middleborough - New Lakeville Station	1,410	77,570	77.5	543.3	44.0
2C-1	NB/FR via Middleborough - New Lakeville Station, Shuttle/transfer	2,030	98,790	98.7	691.9	56.0
3A	NB/FR via Stoughton	4,305	204,250	1430.6	204.1	115.8
3B	NB/FR via Stoughton - DMU Service	3,890	202,135	1415.8	201.9	114.6
4	Commuter Bus	3,385	112,216	112.1	785.9	63.6

[1] VMT = Vehicle Miles of Travel

A full analysis of the traffic impacts and benefits related to each alternative, including traffic issues at station sites, would be performed as part of the next phase of environmental analysis. Some stations will require a MHD curb cut permit for access to state highways. Curb-cuts are needed where more than 200 spaces are proposed or where a change in use would occur.

Environmental Issues Related to the Enhanced Commuter Bus Alternative

The bus routes remain essentially unchanged from the existing condition. The new bus stops at Freetown, East Taunton and Easton, and any existing bus stops where expansion may occur, would experience some increases in noise and traffic levels. There is the potential for some wetland and/or resource impact during park-and-ride construction; any design effort would aim to minimize such impacts.

Table 8 summarizes the potential environmental and community impact of each alternative alignment north of Cotley Junction.

TABLE 8
Summary Comparison of Environmental Issues

	Attleboro Route	Middleborough Route	Stoughton Route
Wetlands	Adverse impacts to 5.4 acres	Adverse impacts to 5,000 s.f.	Adverse impacts to 2 acres within old railbed
100 Year Floodplain	Impacts to floodplain along bypass.	No impacts to floodplain	Restore 1 culvert within floodplain
Waterways	14 crossings, 2 impacts, 400 ft of affected stream	9 crossings, no impacts	24 crossings, new culverts at 2 streams
ACEC	No impact	No impact	Potential effects on wildlife, rare species, and public recreation
Wildlife and Rare Species	Loss of 15 acres of habitat. Construction impacts at Taunton River	No significant effect	Minor loss of habitat Construction impacts at Taunton River Bridge
Noise and Vibration	172 abutters within 150’	41 abutters within 150’	194 abutters within 150’
Grade Crossings	20	5/21[1]	24

[1] Crossings between Lakeville and Cotley / Crossings between Braintree and Lakeville

VI. CAPITAL AND OPERATING COSTS

A. CAPITAL COSTS

As part of the expanded alternatives analysis, a detailed inspection and evaluation of the right-of-ways was performed by the MBTA's engineering consultants. Based on the results of these evaluations, the scope of improvements for each alternative was identified. Capital costs were developed by applying average unit costs from actual bid prices on the Old Colony project.

This evaluation found that the infrastructure upgrades required to construct commuter rail extensions to New Bedford and Fall River would be greater than originally anticipated. In some cases, there are significant differences in costs as compared to the 1995 Feasibility Study. These can be attributed to:

- A more detailed engineering evaluation of the upgrades required.
- Inflation from 1994 to 1996 dollars.
- The need for double track along the proposed Attleboro bypass.
- Identification of additional passing track.
- Installation of a high speed interlocking for connection onto the Northeast Corridor.
- Rerouting of the Stoughton alignment via Weir Junction and the required grade separation at Route 138.
- Installation of a more advanced cab signalling system, consistent with Old Colony design standards.
- Increased bridge rehabilitation costs identified from actual inspection reports.
- The incorporation of design engineering, construction administration and land acquisition costs.

The capital infrastructure costs for each alternative typically consist of the following: new track, bridge rehabilitation, stations, signals and communications, layover facilities, grade crossings, and drainage. The summary of these costs for each alternative is shown in **Table 9**.

Middleborough branch alternatives 2A, 2C and 2C1 have the lowest capital costs, ranging from $252 million to $265 million. These alternatives have the lowest costs because all of the right-of-way is in active use. Service under Alternative 2A, which simply assumes that Old Colony service would be extended to New Bedford and Fall River, has the lowest capital cost. Alternatives 2C and 2C1 involve additional costs for the relocation of Lakeville station. Alternative 2B is similar to Alternative 2A, yet involves and additional $100 million for the construction of a second track along the Old Colony Main Line north of Braintree. The land acquistion costs associated with this double track have not been estimated and would likely increase this estimate significantly.

TABLE 9
Infrastructure Costs by Alternative ($1996)

	Rail Alternative Costs (in $mil)							
	Attleboro		Middleborough				Stoughton	
Project Element	1A	1B	2A	2B	2C	2C1	3A	3B
Track & Right-of-Way	115.9	115.9	96.1	96.1	96.1	96.1	122.5	122.5
Double Track Bypass	22.30	22.30	--	--	--	--	--	--
Layover Facility	4.5	4.5	4.5	4.5	4.5	4.5	6.8	6.8
Retaining Walls	9.1	9.1	2.6	2.6	2.6	2.6	5.6	5.6
Grade Crossings	11.1	11.1	7.4	7.4	7.4	7.4	13.1	13.1
Bridges	31.9	31.9	31.9	31.9	31.9	31.9	49.0	49.0
Intersections/Roadways	7.5	7.5	1.8	1.8	1.8	1.8	2.5	2.5
Stations	22.7	22.7	18.7	18.7	18.7	18.7	33.3	33.3
Signals & Comm.	47.1	47.1	31.4	31.4	31.4	31.4	41.9	41.9
DMU Maint. Facility	--	8.00	--	--	--	--	--	10.0
Reloc. Lakeville Sta.[1]	--	--	--	--	10.0	10.0	--	--
Double Track Main Line				100				
Subtotal	*272.1*	*280.1*	*194.4*	*294.4*	*204.4*	*204.4*	*274.7*	*284.7*
Contingency (10%)	27.2	28.0	19.4	29.4	20.4	20.4	27.5	28.5
Land Acquisition	10.0	10.0	6.0	6.0[2]	6.0	6.0	10.0	10.0
Subtotal	*309.3*	*318.1*	*219.8*	*329.8*	*230.8*	*230.8*	*312.2*	*323.2*
Engineering/Admin.(15%)	46.4	47.7	33.0	49.5	34.6	34.6	46.8	48.5
Total Infrastructure Costs	**$355.7**	**$365.8**	**$252.8**	**$379.3[2]**	**265.4**	**$265.4**	**$359.0**	**$371.7**

[1] Includes FTA reimbursement for abandonment and demolition of the existing station.
[2] Does not include property acquisition or relocation costs north of Braintree.

The Attleboro and Stoughton alternatives are very similar in terms of costs, with the investment required ranging from $355 million to $371 million. These costs are higher due to longer distances for track replacement, and the need for more stations, bridges and structures. The Attleboro alternatives also require $22 million for the bypass track and an interlocking at the Northeast Corridor junction.

The implementation of DMU service would add an additional $8 to 10 million to the cost of each alternative. This cost is for the construction of a dedicated DMU maintenance facility (lower costs for Alternative 1B reflect a smaller facility for fewer trains). The shuttle service operated under Alternatives 2B and 2C1 was assumed to be operated with conventional equipment.

The commuter bus alternative has the lowest capital cost of $13 million. As discussed in the 1995 Feasibility Study, some expansion of the South Station bus terminal would be required to accommodate additional buses each peak period. It was determined that a portion of the parking deck above the new terminal could be utilized to provide six additional bus docks. The estimated cost to modify the upper deck, including improved elevator and escalator access, would be about $2 million. This expansion would provide additional bus capacity for southeastern Massachusetts bus carriers only. An estimated cost for constructing or expanding commuter bus park-ride lots was also included. A cost per space of $3,000 was applied to the total number of new bus riders projected under the enhanced bus alternative. This figure assumes that approximately 2,050 new surface spaces would be constructed for a total cost of $6.2 million. An additional $2 million was incorporated to develop daytime layover capability closer to Boston; no sites were investigated as part of this study. After including a 25% contingency, the total capital costs for enhanced bus service is $13 million.

Equipment estimates were generated based on the ridership forecasts determined for the year 2010. These are shown in **Table 10**, with unit costs based on current MBTA equipment costs. Peak period service at 30 minute headways requires that five trains leave each terminal. With 60 minute headways, this is reduced to two or three trains.

For Alternatives 1A and 3A, four 6-car consists are assigned to New Bedford and Fall River for peak period service. One of these consists would return from South Station in time to run a second peak period run. Alternatives 1B and 3B would have two or three car DMUs leaving each of the terminals at 30 minute intervals and then combining into a four or five car DMU at East Taunton. One reverse peak train could be provided.

Alternatives 2A, 2C and 2C1 are extensions of Middleborough trains and require three additional coaches per train (nine-car trains) to carry the additional ridership. One spare trainset was also assumed to help maintain schedule over the extended track distances.

TABLE 10
Equipment Requirements and Costs ($1996)

Alt. No.	Description	Bi-Level Coaches[1]	Loco-motives[2]	DMU[3]	Buses[4]	Cost ($mil.)
		Equipment Requirements				
1A	NB/FR via Attleboro	24	4	--	--	$51.2
1B	NB/FR via Attleboro - DMUs	--	--	16	--	$40.0
2A	NB/FR via Middleborough	21	1	--	--	$39.8
2B	NB/FR via Middleborough - Skip Stop, Shuttle/Transfer	27[5]	5	--	--	$56.8
2C	NB/FR via Middleborough - Relocated Lakeville Station	21	1	--	--	$39.8
2C-1	NB/FR via Middleborough - Relocated Lakeville Station, Shuttle/Transfer	24[5]	1	--	--	$43.4
3A	NB/FR via Stoughton	24	4	--	--	$51.2
3B	NB/FR via Stoughton - DMUs	--	--	20	--	$50.0
4	Enhanced Bus Service	--	--	--	25	$8.8

1. New bi-level coaches priced at $1.8 million each.
2. New locomotives priced at $2.0 million each.
3. New DMU car has an average price of $2.5 million each.
4. New bus coaches priced at $350,000 each. Bus requirements based on 1,790 new peak period bus passengers. Assumes one-third of buses can recycle.
5. Includes 3 single level coaches for shuttle at $1.2 million each.

In addition to the through-routed trains, Alternative 2B and 2C1 would have conventional three car consists providing alternating 30 minute shuttle service between the terminals and East Taunton. Shuttle passengers would transfer cross-platform to the through-routed consist. A cost analysis found that the cost of operating DMU shuttles would similar to conventional trainsets. If DMUs were utilized elsewhere in the MBTA system in the future, the cost-effectiveness of their use as shuttles would increase.

Total project costs (including infrastructure, equipment, design, land acquisition and administration) are summarized in **Table 11**. This table also calculates the cost per new rider under each alternative.

TABLE 11

Capital Cost Estimates by Alternative ($1996)

Alt. No.	Description	New Track Miles[1]	Total Infrastructure Cost[2] (in $mil.)	Total Equipment Cost (in $mil)	Total Capital Cost (in $mil)	Cost Per New Rider (in $mil)
1A	NB/FR via Attleboro	42.1	$355.70	$51.20	$406.90	$0.19
1B	NB/FR via Attleboro - DMU Service	42.1	$365.80	$40.00	$405.80	$0.21
2A	NB/FR via Middleborough	35.9	$252.80	$39.80	$292.60	$0.29
2B	NB/FR via Middleborough Skip Stop, Shuttle/Transfer	35.9	$379.30	$56.80	$436.10	$0.27
2C	NB/FR via Middleborough Relocated Lakeville Station	35.9	$265.40	$39.80	$305.20	$0.29
2C-1	NB/FR via Middleborough Relocated Lakeville Station, Shuttle/Transfer	35.9	$265.40	$43.40	$308.80	$0.19
3A	NB/FR via Stoughton	46.1	$359.00	$51.20	$410.20	$0.13
3B	NB/FR via Stoughton - DMU Service	46.1	$371.70	$50.00	$421.70	$0.14
4	Enhanced Commuter Bus	192.9	$13.00	$8.8	$21.8	$0.01

1. Track miles reflect only those track segments not currently providing commuter rail service.
2. Infrastructure costs include design, administration, land acquisition and contingencies.

B. OPERATING COSTS

Commuter rail operating costs consist primarily of labor, fuel, train servicing and maintenance, and right-of-way maintenance. The daily train operations costs were determined by taking the total route miles traversed for each alternative and multiplying it by the average gross cost per train mile. The summary of total operating costs for each alternative is shown in **Table 12**.

TABLE 12
Total Operating Costs for Rail and Bus Alternatives ($1996)

Alt. No.	Description	Daily DMU Cost	Daily Conventional Consist Cost	Total Daily Operating Cost
1A	NB/FR via Attleboro	--	$83,685	$83,685
1B	NB/FR via Attleboro - DMU Service	$78,823	--	$78,823
2A	NB/FR via Middleborough	--	$25,367	$25,367
2B	NB/FR via Middleborough - Skip Stop, Shuttle/Transfer	--	$51,793	$51,793
2C	NB/FR via Middleborough - Relocated Lakeville station	--	$24,237	$24,237
2C-1	NB/FR via Middleborough - Relocated Lakeville station, Shuttle/Transfer	--	$38,149	$38,149
3A	NB/FR via Stoughton	--	$73,470	$73,470
3B	NB/FR via Stoughton - DMU Service	$79,114	--	$79,114
4	Enhanced Commuter Bus	-	-	$9,988

For this analysis, an average gross cost per train mile of $39.50 was assumed based on systemwide operations. Costs for DMU service were developed based on experience gained from other DMU operators. Costs vary somewhat depending on consist size, as shown below 1996 dollars.

Description of Service Operated	Gross Cost Per Train Mile
Conventional Locomotive and six coach consist:	$39.50
Shuttle train (locomotive and three coaches):	$34.30
Two-vehicle DMU: Shuttling between NB/FR and East Taunton:	$23.30
Three-vehicle DMU: Shuttling between NB/FR and East Taunton:	$28.50
Four-vehicle DMU: East Taunton to South Station:	$33.70
Five-vehicle DMU: East Taunton to South Station:	$38.80

Gross operating costs for commuter buses are based on a $2.85 per mile average, as provided to the MBTA by SERPEDD and the southeastern Massachusetts private bus carriers.

Daily revenue for each alternative was calculated by multiplying a weighted average one-way fare for each zone by the number of train boardings in that zone, adding revenue across all zones, and multiplying by two, to represent round trips. The weighted average one-way fare for each zone was calculated by assuming that 68% of all passengers use a monthly MBTA pass, with the remaining riders paying full fare. The resulting average fares do not reflect the use of other discounted fares, therefore this daily revenue represents the maximum expected. This methodology is consistent with the 1990 & 1995 Feasibility Studies.

Net daily operating costs were then developed for each alternative by determining the difference between gross operating costs and operating revenues. These estimates represent the actual cost to the MBTA to operate service under each alternative. Operating costs are a function of incremental train miles and shorter alternatives have less expensive annual operating costs. The summary of net operating costs is shown in **Table 13**.

The net daily operating costs for Middleborough service are substantially lower than for other alternatives. This reflects the significantly reduced level of service on Alternatives 2A and 2C and the fact that operating costs between Middleborough and Boston are absorbed as part of Old Colony operations. Alternatives 2B and 2C1 have somewhat higher net costs due to the additional service operated to Boston and/or the East Taunton shuttle.

The Stoughton and Attleboro alternatives are almost twice as costly to operate. Net daily costs for Stoughton are lower due to the more direct route to Boston and the higher ridership potential.

DMU service is more expensive generally due to the higher level of service provided. Twice as many trains operate between the terminals and East Taunton.

The enhanced bus service generates revenue in excess of estimated operations costs. The revenue generated is based on total patrons diverted from both automobiles and other transit.

TABLE 13

Net Daily Operating Costs for Rail and Bus Alternatives ($1996)

Alt. No.	Description	Total Daily Cost	New Transit Riders[1]	Daily Revenue[2]	Net Daily Operating Cost
1A	NB/FR via Attleboro	$83,685	4,360	$24,972	$58,713
1B	NB/FR via Attleboro - DMU Service	$78,823	3,840	$21,792	$57,031
2A	NB/FR via Middleborough	$25,367	1,990	$10,526	$14,841
2B	NB/FR via Middleborough - Skip Stop, Shuttle/Transfer	$51,793	3,230	$16,197	$35,596
2C	NB/FR via Middleborough - Relocated Lakeville station	$24,237	2,140	$11,240	$12,997
2C-1	NB/FR via Middleborough - Relocated Lakeville station	$38,149	3,200	$16,041	$22,108
3A	NB/FR via Stoughton	$73,470	6,080	$30,505	$42,965
3B	NB/FR via Stoughton - DMU Service	$79,114	5,830	$26,378	$52,736
4	Enhanced Bus Service	$9,988	3,580	$14,820	($4,832)

1. Daily Ridership = Inbound Ridership * 2 (only auto diversions included)
2. Daily Revenues for commuter rail and bus are calculated using weighted average fares across eight zones. Average fares are based on a 68% passholder rate (based on MBTA operations) and assume maximum fare generation.

VII. ECONOMIC ANALYSIS

Annualized costs were developed to allow a cost comparison among alternatives that recognizes infrastructure, equipment and operating costs over the extended life of the project. Total annual costs, as shown in **Table 14**, represent the sum of annual operating costs, annualized vehicle purchases and annualized capital costs.

TABLE 14
Life Cycle Costing of Alternatives ($1996)

		Annualized Costs			
Alt. No.	Description	Operating Costs[1] ($mil.)	Equipment Costs ($mil)	Capital Costs ($mil)	Total Costs ($mil)
1A	NB/FR via Attleboro	$26.2	$4.8	$31.6	$62.6
1B	NB/FR via Attleboro - DMU Service	$24.7	$3.7	$32.5	$60.9
2A	NB/FR via Middleborough	$7.9	$3.7	$22.4	$34.0
2B	NB/FR via Middleborough - Skip Stop, Shuttle/Transfer	$16.2	$5.3	$33.7	$55.2
2C	NB/FR via Middleborough - Relocated Lakeville Station	$7.6	$3.7	$23.6	$34.8
2C-1	NB/FR via Middleborough - Relocated Lakeville Station, Shuttle/Transfer	$11.9	$4.1	$23.6	$39.6
3A	NB/FR via Stoughton	$23.0	$4.7	$31.9	$59.6
3B	NB/FR via Stoughton - DMU Service	$24.8	$3.7	$33.0	$61.5
4	Enhanced Bus service	$3.1	$0.8	$0.9	$4.8

1. Annual Operating Costs = daily operating cost * 261 weekdays, plus 50% service assumed on weekends.

Annual operating costs assume the daily operating costs would apply for 261 weekdays with reduced service on weekends. Equipment costs and capital costs were annualized based on an 8% interest rate. Rail equipment was assumed to have a vehicle life of 25 years, buses were assumed to have a vehicle life of 12 years. Capital costs for trackwork and other right-of-way improvements assumed a structure life of 30 years. Operating costs are a function of incremental train miles and shorter alternatives have less expensive annual operating costs.

Middleborough alternatives would have the lowest annualized costs. These overall costs are substantially lower for Alternatives 2A, 2C and 2C-1 because operating miles and capital infrastructure needs are substantially less than needed on either the Attleboro or Stoughton routes. Alternative 2B, which would require the construction of a double track along the Old Colony Main Line north of Braintree, would have annualized costs that are in the same range as Attleboro and Stoughton.

Table 15 presents the net operating costs and fare box recovery ratios for each alternative. Net operating costs are a function of incremental route miles and ridership. Corridors that have high total operating costs can still have reasonable net operating costs if ridership is high. The fare box recovery ratio reflects the percentage of total operating costs offset by fare collection.

Fare box recovery would be greatest for the Stoughton and some Middleborough options. The cost-effectiveness of the Stoughton service is a result of high ridership which offsets relatively long operating distances. The cost-effectiveness of the Middleborough routes is greatest for those which operated as extensions of Old Colony service. Although ridership is relatively low, the numbers reflect that much of the operating costs are absorbed into the Old Colony System.

The lowest fare box recovery ratios are shown for the Attleboro route and the Middleborough option which adds dedicated New Bedford/Fall River trains.

TABLE 15

Net Annual Operating Costs and Fare Box Recovery Ratios ($1996)

			Annual Cost (in $ millions)			
Alt. No.	Description	New Annual Riders[1]	Total Operating Cost	Revenue[2]	Net Operating Cost	Fare Box Ratio
1A	NB/FR via Attleboro	614,324	$26.2	$7.0	$19.2	.27
1B	NB/FR via Attleboro - DMU Service	541,056	$24.7	$6.1	$18.6	.25
2A	NB/FR via Middleborough	280,391	$7.9	$3.0	$4.9	.38
2B	NB/FR via Middleborough - Skip Stop	455,107	$16.2	$4.6	$11.6	.28
2C	NB/FR via Middleborough - Relocated Lakeville Station	301,526	$7.6	$3.2	$4.4	.42
2C-1	NB/FR via Middleborough - New Lakeville Sta., Shuttle/Transfer	450,880	$11.9	$4.5	$7.4	.38
3A	NB/FR via Stoughton	856,672	$23.0	$8.6	$14.4	.37
3B	NB/FR via Stoughton - DMU Service	821,447	$24.8	$7.4	$17.4	.29
4	Enhanced Bus Service	504,422	$3.1	$4.2	($1.2)	1.35

1. Annual new inbound trips(auto diversions), including 20% weekend ridership
2. Annual revenue includes 261 weekdays, plus weekend revenue at 20% of weekday revenue.

VIII. SUMMARY OF RESULTS

The analysis performed as part of this Expanded Alternatives Analysis is summarized below. A summary of the costs and benefits of each alternative considered can be found in **Table 16**.

Ridership Potential of the Alternatives

- An extension via the Stoughton Branch would have the highest ridership with 4,325 daily inbound train boardings. In terms of diverting commuters from the automobile and achieving air quality benefits, this alternative would also be the best. An extension via Attleboro would have slightly lower boardings of 3,230.

- Only Alternatives 1A or 3A, with service via Attleboro or Stoughton, would attract ridership at levels comparable to other MBTA commuter rail lines.

- DMU alternatives along either the Stoughton or Attleboro route offer twice as much service to Fall River and New Bedford, but ridership is 6 to 10 percent lower. This is due to current federal regulations which add a 7 to 12 minute time penalty for brake tests during DMU coupling.

- The commuter bus option would increase existing bus ridership by more than 100 percent. More than 3,500 passengers would use enhanced New Bedford, Fall River and Taunton bus service due to lower fares, free transfers to the MBTA rapid transit system and increased commuter parking availability. An estimated 1,790 of these commuters would be diverted from automobiles.

- Middleborough alternatives which simply extend Old Colony service have the lowest ridership potential with only 1,300 to 1,400 boardings. Middleborough options with more competitive travel times and increased service levels still attract 35 to 50 percent less ridership (about 2,045 inbound boardings) than the Attleboro and Stoughton options.

- The use of supplemental shuttle service to increase ridership on the Middleborough line alternatives could also be applied to the Stoughton and Attleboro alternatives. This would further increase ridership levels on these routes and amplify the relative benefits of these routes as compared to the Middleborough line options. The relocation of Lakeville station would reduce travel time by about 10 minutes, but would have a minimal impact on ridership.

- Low ridership on the Middleborough alternatives is due in part to the fact that these options do not serve Back Bay station. Back Bay station is the ultimate destination for 40 percent of existing MBTA commuter rail passengers on the south side.

- The North Easton and East Taunton stations are the highest ridership generators, with potentially over 1,000 passengers each.

Potential Environmental Impacts

- The level of potential impact is minimal to nonexistent along the Middleborough route. The Attleboro and Stoughton routes have a much greater potential for environmental and community impacts.

- Wetland impacts would be minor along the Middleborough route (5,000 square feet), more significant along the Stoughton route (2 acres) and most significant along the Attleboro bypass (5.4 acres).

- Both the Stoughton and Attleboro routes would require wetlands variances. While the Stoughton route has fewer wetland impacts than Attleboro, it passes through the Hockomock Swamp Area of Critical Environmental Concern (ACEC) and may be more difficult to permit.

- The Stoughton route would result in noise impacts to the largest number of abutting residential and commercial properties. Furthermore, there is currently no train traffic along this proposed right-of-way. The Attleboro route would also impact many residential and commercial properties, but these properties currently abut an active railroad right-of-way.

- The number of grade crossings is greatest along the Stoughton alignment. All 24 of these at-grade crossings would be new. The Attleboro alignment would have 20 grade crossings, but only one is not in existence today. Three of the Middleborough alternatives would involve 5 existing grade crossings. Alternative 2B however, due to increased train operations, would involve the 21 crossings located along the Middleborough Line between Braintree and Lakeville.

Operational Issues

- The level of service assumed previously on the Northeast Corridor has been reduced somewhat from the 1995 Feasibility Study levels as a result of a detailed simulation of operations along this route. The number of trains passing through Taunton, Norton, and Attleboro along the so-called Attleboro route would be 36 daily (as opposed to 44).

- Schedules for the three Old Colony branches are uncompromising ones that have been developed to work within Main Line capacity constraints. Even without New Bedford/Fall River service, it will be challenging to maintain acceptable levels of on-time performance on the Old Colony system.

- Middleborough alternatives which simply extend service (2A, 2C and 2C-1) would not be able to accommodate both New Bedford/Fall River and Old Colony passengers without adding additional trains. The addition of New Bedford/Fall River passengers could put Old Colony Middleborough line service 27 percent over MBTA service standards for passenger loading.

- The addition of New Bedford and Fall River trains to the tightly constrained Old Colony Main Line was tested under Alternative 2B. The results demonstrated that increased train traffic would have significant impacts on the level of service provided to Old Colony passengers. During the AM peak, virtually all trains travelling the Main Line to South Station would be delayed. During the PM peak, all service would be late with the exception of one train. These delays could dead-lock service on all three Old Colony branches affecting the daily commute for more than 15,000 Old Colony passengers.

- Even Middleborough alternatives which do not add additional trains but simply extend planned Old Colony service would increase the potential for delays. The longer distances covered by each train would inhibit the ability to recover from minor service disruptions.

- Additional capacity can be added to the Old Colony system only by adding a second track north of Braintree. The level of development along this corridor in Dorchester and Quincy would require numerous property takings. Construction of a second track would cost over $100 million in infrastructure, plus land acquisition and relocation costs of a significant magnitude.

- Relocation of the Middleborough/Lakeville terminal as presently being constructed as part of the Old Colony project would be feasible. However, relocation would require the MBTA to rescind commitments made as part of the Old Colony project and to reimburse the FTA for design and construction costs of up to $5 million. Relocation would have minimal impact on ridership.

- It is recommended that the capacity of South Station, regardless of the alignment selected, be further investigated following the selection of a preferred alignment. This would be particularly important for any option that increased service on the Old Colony system, because the two platforms dedicated for Old Colony trains would be unable to accommodate additional trains during the peak periods.

The Use of Diesel Multiple Units

- In short consists, DMUs are more efficient to operate and maintain than locomotive-hauled equipment of similar capacity. However, the higher costs for each individual car limits their advantage to consists with less than 400-600 passengers.

- FRA safety regulations currently limit the realization of the full operational benefits of DMU technology. The need to perform a full brake test when coupling adds a 7 to 12 minute time penalty to each trip and reduces ridership potential.

- The cost and operational advantages of operating DMUs as short-haul shuttles should be further evaluated by the MBTA. The cost-effectiveness of such applications would increase if introduced in several places in the MBTA system.

Capital Costs

- The Attleboro and Stoughton alternatives are very similar in terms of total project costs, with the investment required ranging from $407 million to $410 million. The only feasible way to route service via Middleborough is by adding more trains, as evaluated under Alternative 2B. The need to double track the Old Colony Main Line north of Braintree would make this the most expensive alignment with total project costs estimated at $436 million *plus* property acquisiton and relocation. Middleborough branch alternatives 2A, 2C and 2C-1 have the lowest overall project costs, ranging from $293 million to $310 million, but these options are not feasible.

- Attleboro costs have increased from what was originally anticipated. The difference is due mainly to: the need for double track along the bypass; grade separation at Route 123; and the need to replace (rather than simply upgrade) track along the Attleboro Secondary.

- The implementation of DMU service would add an additional $8 to $10 million to the cost of each alternative for a dedicated maintenance facility.

- The commuter bus alternative has the lowest overall project cost of about $22 million. These costs cover modifications to South Station, construction of 2,050 parking spaces, and the purchase of additional buses.

- The Stoughton alternative represents an option with very high service levels. Total project costs for this alternative could be reduced by about $20 million by buying less equipment and stopping New Bedford/Fall River trains at all Stoughton branch local stops.

- All costs are in 1996 dollars. Inflation to the year 2000 or more would provide a more realistic estimate of expected costs.

Operating Costs

- The net daily operating costs for Middleborough alternatives are substantially lower than for other alternatives. This reflects the lower levels of service on these routes and the fact that operating costs north of Middleborough are absorbed as part of Old Colony operations.

TABLE 16
Summary of Alternatives

(Costs in Millions$)

Alt. No.	Description	Daily Inbound Transit Riders	New Transit Riders[1]	Total Infrastructure Costs[2]	Total Equipment Costs	Annual Operations Costs	Total Annualized Costs	Cost per New Rider [3]
1A	NB/FR via Attleboro	3,620	2,180	$355.70	$51.20	$26.20	$62.60	$0.19
1B	NB/FR via Attleboro - DMU Service	3,370	1,920	$365.80	$40.00	$24.70	$60.90	$0.21
2A	NB/FR via Middleboro	2,430	995	$252.80	$39.80	$7.90	$34.00	$0.29
2B	NB/FR via Middleboro - Skip Stop, Shuttle/Transfer	3,040	1,615	$379.30	$56.80	$16.20	$55.20	$0.27
2C	NB/FR via Middleboro - Relocated Lakeville Station	2,500	1,070	$265.40	$39.80	$7.60	$34.80	$0.29
2C-1	NB/FR via Middleboro - Relocated Lakeville Station, Shuttle/Transfer	3,045	1,600	$265.40	$43.40	$11.90	$39.60	$0.19
3A	NB/FR via Stoughton	4,485	3,040	$359.00	$51.20	$23.00	$59.60	$0.13
3B	NB/FR via Stoughton - DMU Service	4,360	2,915	$371.70	$50.00	$24.80	$61.50	$0.14
4	Enhanced Bus service	3,500	1,790	$13.00	$8.80	$3.10	$4.80	$0.01

1. Total inbound trips diverted from the automobile mode
2. Includes design, administation, contingencies and land acquisition.
3. Total capital cost (infrastructure + equipment) / New transit riders

- The Stoughton and Attleboro alternatives are almost twice as costly to operate than Middleborough options. Net daily costs for Stoughton are somewhat lower due to this alignment's more direct route to Boston as well as its higher ridership potential.
- DMU service operated via Attleboro or Stoughton would have gross operating costs that are in the same range as traditional equipment. However, longer travel times and lower ridership result in higher net operating costs for the DMU service.

Overall Cost Effectiveness

An extension via Stoughton would be the most cost-effective commuter rail alternative, with a fare box recovery of 37 percent and a $130,000 investment per new transit rider. An extension via Attleboro would have a fare box recovery of 27 percent and require a $190,000 investment per new rider.

Three Middleborough alternatives (2A, 2C and 2C-1) appear to have high fare box recovery ratios of 38 to 42 percent, but these options would not be feasible without constructing a second track north of Braintree and running more service to accomodate all passengers. Alternative 2B offers this additional service and, as a result, has a lower fare recovery ratio of 28 percent, about the same as the Attleboro route. The cost per new rider along the Middleborough route would be the highest, and at $270,000 represents twice the investment required to attract new passengers along the Stoughton route. The cost-effectiveness of the Middleborough route would be further reduced once the actual costs of property acquisition in Dorchester and Quincy were factored in.

Analysis of the commuter bus alternative demonstrates that incremental fares would exceed the incremental operating costs.

Ridership Analysis Update
March 1997

Attachment #1

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CENTRAL
TRANSPORTATION
PLANNING
STAFF

MEMORANDUM

TO: Anne Galbraith, Erick Scheier, MBTA March 14, 1997

FROM: Vijay Mahal

RE: New Bedford/Fall River Commuter Rail Extension Study Update: Results of the Ridership Analysis

INTRODUCTION / SUMMARY

This memorandum presents the ridership results for all the New Bedford/Fall River alternatives developed recently. Most of the level-of-service data used in modeling these alternatives were obtained from LSTS.

The results of our ridership analysis indicate the Stoughton alternative (Alt 3A, using standard consists) would generate the highest ridership of about 4,325 inbound trips per day. The use of DMU's on the Stoughton alignment (Alt 3B) would reduce this ridership to around 3,900 inbound trips per day. The Stoughton alternatives would divert most of the bus riders to the train mode. In addition, they would divert approximately 3,000 inbound automobile trips to the commuter rail. This auto diversion would contribute to a reduction of about 204,000 of VMT in the study area.

The enhanced bus alternative (Alt 4) produces the next highest ridership of around 3,500 inbound trips. The bus alternative includes improving the service by means of increased frequency and rerouting every other bus to serve the Back Bay area. The new park and ride lot planned at West Bridgewater would attract about 115 trips.

The Attleboro Bypass alternative (Alt 1A, using standard consists) is projected to generate about 3,400 inbound trips per day. The use of DMU's on the Attleboro Bypass alternative (Alt 1B) would reduce this ridership to about 3,200 trips per day. About one-third of the commuter rail ridership would be as a result of diversion from the bus mode.

The Middleboro alternatives perform poorly in comparison to other alternatives. The ridership on the Middleboro alternative range from 1,300 to 2,050 inbound trips per day. The operational constraints on the Old Colony main line basically dictate the level-of-service along the Middleboro alignment. Longer travel times, reverse move, forced transfer at E. Taunton, inability to serve the Back Bay Station and fewer number of trains are some of the reasons why the Middleboro alternatives generate low ridership.

The first part of this memorandum highlights the network and service assumptions used in each alternative and the second part discusses the results in some detail. Table 1A summarizes the ridership results for all alternatives. Tables 1 through 9 present detailed information on commuter rail ridership, bus ridership, auto diversion and air quality impacts for each alternative.

.Level of Service Assumptions

Alternative 1A. ATTLEBORO BYPASS -Standard Consists

- alignment through Attleboro Bypass
- stations in Taunton Center, East Taunton, Freetown, Fall River, New Bedford
- NB/FR trains would stop at Sharon station and run express to Ruggles
- Providence trains would skip Sharon station
- about 36 trains per day (60 min Peak Headway, 2 hour Off Peak Headway from each town)
- one-way trip time would be approximately 1 hour and 12 minutes

Alternative 1B. ATTLEBORO - DMU Service

- alignment through Attleboro Bypass
- stations in Taunton Center, East Taunton, Freetown, Fall River, New Bedford
- also stops at Sharon and runs express to Ruggles
- about 36 trains per day per town (30 min Peak Hdway, 1 hour Off Peak Hdway)
- DMU s split and join at East Taunton Station to serve both NB and FR
- a delay of 5 minutes assumed between train arrivals at East Taunton
- coupling time for the DMU s would be 7 minutes
- one-way trip time would be approximately 1 hour and 24 minutes

Alternative 2A. MIDDLEBORO- Standard Consists

- extension of the planned Old Colony Middleboro Line
- reverse move at Lakeville
- new station in E.Taunton to avoid a second reverse move
- theoretically 26 trains per day
- alternating consists to Fall River and New Bedford during the peak period
- one new stop at JFK assumed on the main line
- one-way trip time would be approximately 1 hour and 36 minutes

Alternative 2B. MIDDLEBORO- Tandem Express

- extension of the planned Old Colony Middleboro Line
- about 18 trains per branch per day

- about 13 inbound trains from Middleboro
- alternating service to/from NB/FR during the peak period
- alternating shuttle service from NB/FR to provide cross platform transfer at East Taunton
- a second set of new tracks between Myricks Jct. and E. Taunton
- NB/FR trains stop at all outlying stations plus at Bridgewater, Brockton, Holbrook/ Randolph and Quincy Center and JFK
- Old Colony Middleboro trains stop at Lakeville, Campello, Montello, Braintree, Quincy Center and JFK station
- one-way trip time would be approximately 1 hour and 17 minutes

Alternative 2C. MIDDLEBORO- Standard Consists, New Lakeville Station

- extension of the planned Old Colony Middleboro Line
- new Lakeville station off of Rte 18 and Taunton St. on the Middleboro Secondary
- theoretically 26 trains per day
- alternating consists to Fall River and New Bedford during peak the period
- one new stop at JFK assumed on the main line
- one-way trip time would be approximately 1 hour and 26 minutes

Alternative 2C-1. MIDDLEBORO- Standard Consists, New Lakeville Station (Shuttle from NB/FR to provide cross platform transfer at E.Taunton)

- extension of the planned Old Colony Middleboro Line
- new Lakeville station off of Rte 18 and Taunton St. on the Middleboro Secondary
- theoretically 26 trains per day per branch
- alternating consists to Fall River and New Bedford during the peak period
- alternating shuttle service from NB/FR to provide cross platform transfer at East Taunton
- one new stop at JFK assumed on the main line
- one-way trip time would be approximately 1 hour and 30 minutes

Alternative 3A. STOUGHTON - Standard Consists

- extension of the existing Stoughton Line to N.Easton
- use Weir Junction, with Dean Street instead of Taunton Center
- 34 trains per day (17 to/from FR and 17 to/from NB)
- one-way trip time would be approximately 1 hour 13 minutes
- New Bedford/Fall River trains stop at Freetown, E.Taunton, Taunton, Raynham, N.Easton and run express to Ruggles
- N.Easton local will stop at Stoughton, Canton Jct.,Route 128, Hyde Park and

Ruggles

Alternative 3B. STOUGHTON - DMU Service

- extension of the existing Stoughton Line to N.Easton
- DMU s split and join at E. Taunton to serve both NB and FR
- all NB/FR stops then runs express from N.Easton to Ruggles
- a delay of 5 minutes assumed between train arrivals at East Taunton
- coupling time for the DMU s would be 7 minutes
- 34 trains per branch per day
- one-way trip time would be approximately 1 hour and 25 minutes
- N.Easton local will stop at Stoughton, Canton Jct.,Route 128, Hyde Park and Ruggles

Alternative 4. IMPROVED BUS SERVICE

- peak headways of 15 min on all buses from Fall River, New Bedford and Taunton
- bus routes will have similar stopping pattern as rail alternatives
- bus fares would be comparable to rail fares
- park and ride lots planned at Fall River, New Bedford, Freetown, E.Taunton, Raynham, Taunton and Easton
- some additional terminal capacity to be provided at South Station
- all buses are assumed to use the HOV lanes on SE Expressway

MODEL RESULTS

The results of the ridership analysis are summarized in Table 1A. More detailed information on ridership and air quality impacts for each alternative are shown in Tables 1 through 9. As seen from Table 1A, the Stoughton alternative using standard consists produces the highest commuter rail ridership (about 4,325 inbound trips) per day. About one third of the commuter rail ridership would come from the private bus mode. This alternative would divert roughly 3,000 inbound auto trips to transit which would result in a reduction of about 204,250 Vehicle-Miles-of Travel (VMT) in the study area.

The DMU's in Alternative 3B generate the next highest ridership i.e. about 3,900 inbound trips per day. Though the DMUs would require 12 minutes additional penalty for coupling, brake testing etc., they still produce good ridership when compared to Alt 3A. This is mainly because of the doubling of the train frequency from each branch. That is, Alternative 3A provides 34 trains per day (17 per branch) whereas the DMU alternative (3B) provides 34 trains per branch.

The Attleboro Bypass alternative which uses the standard consists (Alt1A) is projected to produce about 3,400 inbound trips per day. When DMUs are used on this alignment as in Alt 1B, the ridership reduces by only about 200. The coupling procedure for the DMUs increases the travel time to all those passengers south of E.Taunton by about 12 minutes. As seen from Table 2, there is a significant decrease in ridership New Bedford, Fall River and Freetown and a noticeable increase at E.Taunton. Most passengers from New Bedford, Fall River and Freetown appear to be driving directly to E. Taunton station to avoid the 12 minute coupling penalty. Though the number of trains from New Bedford and Fall River would be doubled in this alternative (when compared to 1A), the ridership at the outlying stations would still be low due to the 12 minute.

The Middleboro alternatives, Alt 2A, 2B,2C and 2C-1 perform poorly when compared to other alternatives. The main reasons for this are fewer trains, longer travel times, an undesirable reverse move, a forced Shuttle transfer at E.Taunton and the inability to serve the Back Bay Station.

Alternative 2A which involves a reverse move has an excessively long travel time of 1 hr and 36 minutes. This results in a low ridership of only 1,320 inbound trips per day. Alternative 2B consists of running Tandem express service using a skip stop pattern. Though this alternative provides a much shorter travel time and increased frequency compared to 2A, it still does not increase the ridership significantly because of the forced shuttle transfer at E.Taunton.

Alternative 2C provides a slightly better travel time (10 minutes less) than 2A but still does not generate attractive ridership. Of all the Middleboro alternatives, 2C-1 has the most frequent service, 26 trains per branch. As a result, it is projected to produce as much ridership as 2B inspite of a longer travel time and a forced Shuttle transfer at E.Taunton.

The enhanced bus alternative, Alt 4 produces a healthy ridership of about 3,500 inbound trips per day. Nearly half of this ridership would be coming from the automobile mode and the other half would be comprised of those already using the bus mode in the absence of commuter rail.

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Table 7: New Bedford / Fall River Commuter Rail Extension

Expanded Feasibility Study Update

ALTERNATIVE 3A (Standard Consists)
New Bedford/Fall River to S.Station (via the Stoughton Alignment)

Peak Headway=30min. Off Peak Headway=120 min. No: of trains per day=34
Oneway trip time= 1 hour and 13 min
Fall River trains stop at Freetown, Dean St., Raynham, N.Easton, Canton JCT, Rte 128 & Hyde Park
New Bedford trains stop at E.Taunton, N.Easton, Stoughton, Canton Ctr, Canton Jct & Rte 128
Uses Weir Junction, with Dean Street Station instead of Taunton Center
Fare=$4.75, Free transfers to Subway in downtown

Year 2010 Demand Forecasts

Total Daily Inbound Person Trips from the study area to the Boston CBD/E.Cambridge

Commuter Rail Ridership (all trip purposes included)

Station	*Inbound Person Trips*	*Walk Access Trips*	*Drive Access Trips*	*Parking Demand Estimate*
Fall River	620	30	590	515
Freetown	430	0	430	375
New Bedford	600	30	570	500
East Taunton	875	0	875	760
Dean Street Station	400	15	385	335
Raynham	300	0	300	260
N.Easton	1,100	15	1,085	945
Total	4,325	90	4,235	3,690

Sources of Trips	
Trips diverted from the Auto Mode	3,040
Trips diverted from other Transit	1,285

Bus Ridership (all trip purposes included)

Station	*Inbound Boardings*
Fall River	35
New Bedford	50
Taunton	75
Raynham	
Total	*160*

Air Quality Impacts (for the study area)
Daily estimates

Total VMT savings	204,250	Veh miles/day
CO Emission Reduction	204.05	Kg/day
NOx Emissions Reduction	1430.57	Kg/day
VOC Emissions Reduction	115.81	Kg/day

Table 1: New Bedford / Fall River Commuter Rail Extension

Expanded Feasibility Study Update

ALTERNATIVE 1A (using standard consists)
New Bedford/Fall River to S.Station (via the Attleboro Bypass)

Peak Headway=60 min, Off Peak Headway= 120 min from each town, No: of trains per day= 36
Oneway trip time= 1 hour and 12 min (from New Bedford), 1 hour and 14 min (from Fall River)
Providence trains do not stop at Sharon but New Bedford/FallRiver trains do.
Fare= $4.75, Free transfers to Subway in downtown

Year 2010 Demand Forecasts

Total Daily Inbound Person Trips from the study area to the Boston CBD/E.Cambridge

Commuter Rail Ridership (all trip purposes included)

Station	*Inbound Person Trips*	*Walk Access Trips*	*Drive Access Trips*	*Parking Demand Estimate*
Fall River	650	20	630	565
Freetown	475	0	475	415
New Bedford	700	25	675	610
East Taunton	860	0	860	750
Taunton Center	545	10	535	475
Sharon (new trips)	150	0	160	130
Total	**3,380**	**55**	**3,335**	**2,945**

Sharon (total boarding: NB/FR trains only)	1,120

Sources of Trips	
Trips diverted from the Auto Mode	2,330
Trips diverted from other Transit	1,050

Bus Ridership (all trip purposes included)

Station	*Inbound Boardings*
Fall River	45
New Bedford	155
Taunton	135
Raynham	55
Total	***390***

Air Quality Impacts (for the study area)
Daily estimates

Total VMT savings	169,290	Veh miles/day
CO Emission Reduction	169.12	Kg/day
NOx Emissions Reduction	1185.71	Kg/day
VOC Emissions Reduction	95.99	Kg/day

Table 1A: NEW BEDFORD/FALL RIVER COMMUTER RAIL EXTENSION STUDY UPDATE
YEAR 2010 RIDERSHIP FORECASTS

Sub Mode description	Base Year counts	2010 No Build	Alt 1A Attleboro Std consists	Alt 1B Attleboro DMUs	Alt 2A Middleboro Std consists (reverse move)	Alt 2B Middleboro Tandem exp (Shuttle transfer at E.Taunton)	Alt 2C Middleboro Std consists (No reverse move, new Lakeville Stn)	Alt 2C-1 Middleboro Std consists (No reverse move, new Lakeville Stn, Shuttle transfer at E.Taunton)	Alt 3A Stoughton Std consists	Alt 3B Stoughton DMUs	Alt 4 Commuter bus
No: of trains/day			36	36/branch	26	18 per branch	26	26 per branch	34	34/branch	varies by
Travel time			1hr-12min	1hr-24min	1hr-36min	1hr-17min	1 hr 26 min	1 hr 30 min	1 hr 13 min	1hr-25min	route
Commuter Rail											
Total daily inbound boardings at all new stations on the extn.	----	----	3,380	3,180	1,320	2,045	1,410	2,030	4,325	3,890	----
Private Bus carriers											
Total daily inbound boardings from the study area	700	1,450	390	400	1,110	995	1,090	1,015	160	470	3,500
Diversions											
Total inbound trips diverted from the automobile mode	----	----	2,330	2,130	995	1,615	1,070	1,600	3,040	2,915	1,790
Total inbound trips diverted from other transit modes	----	----	1,050	1,050	325	445	340	430	1,285	975	1,710
Air Quality estimates for the study area											
Total VMT reduction	----	----	169,290	137,470	72,110	99,765	77,570	98,790	204,250	202,135	112,216
CO reduction (Kg/day)	----	----	169.12	137.33	505.06	698.75	543.3	691.93	204.05	201.93	785.96
NOx reduction (Kg/day	----	----	1185.71	962.84	72.04	99.67	77.49	98.69	1430.57	1415.75	112.1
VOC reduction (Kg/da	----	----	95.99	77.95	40.89	56.57	43.98	56.01	115.81	114.61	63.63

Table 2: New Bedford / Fall River Commuter Rail Extension
Expanded Feasibility Study Update

ALTERNATIVE 1B (using DMU vehicle technology)
New Bedford/Fall River to S.Station (via the Attleboro Bypass)

Peak Headway=30 min, Off Peak Headway= 60 min, No: of trains per day=36 per branch
Oneway trip time= 1 hour and 24 min (from New Bedford), 1 hour and 26 min (from Fall River)
DMU s split and join at E. Taunton to serve both FR and NB
Fare= $4.75. Free transfers to Subway in downtown

Year 2010 Demand Forecasts
Total Daily Inbound Person Trips from the study area to the Boston CBD/E.Cambridge

Commuter Rail Ridership (all trip purposes included)

Station	*Inbound Person Trips*	*Walk Access Trips*	*Drive Access Trips*	*Parking Demand Estimate*
Fall River	370	20	350	300
Freetown	250	0	250	220
New Bedford	400	25	375	325
East Taunton	1,450	0	1,450	1260
Taunton Center	500	10	490	425
Sharon (new trips)	210	0	210	180
Total	**3,180**	**55**	**3,125**	**2,710**

Sharon	1,170

Sources of Trips

Trips diverted from the Auto Mode	2,130
Trips diverted from other Transit	1,050

Bus Ridership (all trip purposes included)

Station	*Inbound Boardings*
Fall River	15
New Bedford	180
Taunton	150
Raynham	55
Total	***400***

Air Quality Impacts (for the study area)
Daily estimates

Total VMT savings	137,470	Veh miles/day
CO Emission Reduction	137.33	Kg/day
NOx Emissions Reduction	962.84	Kg/day
VOC Emissions Reduction	77.95	Kg/day

Table 3: New Bedford / Fall River Commuter Rail Extension

Expanded Feasibility Study

ALTERNATIVE 2A
Fall River to S. Station via the Middleboro Line
(Reverse Move at Lakeville)

Peak Hdway=60 min, Off Peak Hdway=120 min from each town
Oneway trip time= 1 hour and 36 min, No of trains per day= 26(theoretical)
Alternating trains from NB and FR during the peak period
One new stop at JFK assumed on the main line
New station at E. Taunton to avoid a second reverse move
Fare=$4.75, Free transfers to Subway in downtown

Year 2010 Demand Forecasts

Total Daily Inbound Person Trips from the study area to the Boston CBD/E.Cambridge

Commuter Rail Ridership (all trip purposes included)

Station	*Inbound Person Trips*	*Walk Access Trips*	*Drive Access Trips*	*Parking Demand Estimate*
Fall River	350	20	330	305
Freetown	165	0	165	145
New Bedford	390	20	370	340
East Taunton	415	0	415	360
Total	1,320	40	1,280	1,150

Lakeville/Middleboro	190	0	190	165

Sources of Trips	
Trips diverted from the Auto Mode	995
Trips diverted from other Transit	325

Bus Ridership (all trip purposes included)

Station	*Inbound Boardings*
Fall River	325
New Bedford	330
Taunton	400
Raynham	55
Total	*1,110*

Air Quality Impacts (for the study area)
Daily estimates

Total VMT savings	72,110	Veh miles/day
CO Emission Reduction	505.06	Kg/day
NOx Emissions Reduction	72.04	Kg/day
VOC Emissions Reduction	40.89	Kg/day

Table 4: New Bedford / Fall River Commuter Rail Extension

Expanded Feasibility Study

ALTERNATIVE 2B
Fall River to S. Station via the Middleboro Line
(Tandem Express)

About 13 inbound trains from Middleboro, second set od tracks between Myricks Jct and E.Taunton
Oneway trip time= 1 hour and 17 min. No: of trains per day=18 from each town
Alternating service during peak period to/from NB and FR
Alternating shuttle service from NB/FR to provide cross platform transfer at E. Taunton
NB/FR trains stop at all outlying stations plus at Bridgewater, Brockton, Holbrook/Randolph, Q.Ctr &JFK
Old Colony Middleboro service stops at Lakeville, Campello, Montello , Braintree, Q.Ctr & JFK stations
Fare =$4.75, Free transfers to Subway in downtown

Year 2010 Demand Forecasts

Total Daily Inbound Person Trips from the study area to the Boston CBD/E.Cambridge

Commuter Rail Ridership (all trip purposes included)

Station	*Inbound Person Trips*	*Walk Access Trips*	*Drive Access Trips*	*Parking Demand Estimate*
Fall River	490	20	470	410
Freetown	275	0	275	240
New Bedford	585	20	565	490
East Taunton	695	0	695	600
Total	2,045	40	2,005	1,740

Lakeville/Middleboro	210	0	210	180

Sources of Trips	
Trips diverted from the Auto Mode	1,615
Trips diverted from other Transit	445

Bus Ridership (all trip purposes included)

Station	*Inbound Boardings*
Fall River	260
New Bedford	280
Taunton	395
Raynham	60
Total	*995*

Air Quality Impacts (for the study area)
Daily estimates

Total VMT savings	99,765	Veh miles/day
CO Emission Reduction	698.75	Kg/day
NOx Emissions Reduction	99.67	Kg/day
VOC Emissions Reduction	56.57	Kg/day

Table 5: New Bedford / Fall River Commuter Rail Extension

Expanded Feasibility Study

ALTERNATIVE 2C (Standard Consists)
Fall River to S. Station via the Middleboro Line
Lakeville Station relocated to a new site off of Rte 18 and Taunton St. on the Middleboro Secondary
Peak Hdway=60 min. Off Peak Hdway=120 min from each town
Oneway trip time= 1 hour and 26 min. No: of trains per day=26 (theoretical)
Alternating trains from NB and FR during the peak period
Fare=$4.75, Free transfers to Subway in downtown

Year 2010 Demand Forecasts

Total Daily Inbound Person Trips from the study area to the Boston CBD/E.Cambridge

Commuter Rail Ridership (all trip purposes included)

Station	*Inbound Person Trips*	*Walk Access Trips*	*Drive Access Trips*	*Parking Demand Estimate*
Fall River	375	20	355	310
Freetown	175	0	175	150
New Bedford	415	30	385	335
East Taunton	445	0	445	385
Total	1,410	50	1,360	1,180

N.Lakeville (new stop)	190	0	190	165

Sources of Trips	
Trips diverted from the Auto Mode	1,070
Trips diverted from other Transit	340

Bus Ridership (all trip purposes included)

Station	*Inbound Boardings*
Fall River	300
New Bedford	335
Taunton	400
Raynham	55
Total	*1,090*

Air Quality Impacts (for the study area)
Daily estimates

Total VMT savings	77,570	Veh miles/day
CO Emission Reduction	543.30	Kg/day
NOx Emissions Reduction	77.49	Kg/day
VOC Emissions Reduction	43.98	Kg/day

Table 6: New Bedford / Fall River Commuter Rail Extension
Expanded Feasibility Study

ALTERNATIVE 2C-1 (Std. Consists, Shuttle transfer at E.Taunton)
Fall River to S. Station via the Middleboro Line
Lakeville Station relocated to a new site off of Rte 18 and Taunton St. on the Middleboro Secondary
Peak Hdway=30 min, Off Peak Hdway=60 min from each town
Oneway trip time= 1 hour and 30 min, No: of trains per day=26(theoretical) per branch
Alternating trains from NB and FR during the peak period
Alternating shuttle from NB/FR to provide cross platform transfer at E.Taunton
Fare=$4.75, Free transfers to Subway in downtown

Year 2010 Demand Forecasts
Total Daily Inbound Person Trips from the study area to the Boston CBD/E.Cambridge

Commuter Rail Ridership (all trip purposes included)

Station	*Inbound Person Trips*	*Walk Access Trips*	*Drive Access Trips*	*Parking Demand Estimate*
Fall River	480	20	460	400
Freetown	270	0	270	235
New Bedford	570	30	540	470
East Taunton	710	0	710	615
Total	2,030	50	1,980	1,720

N.Lakeville (new stop)	200	0	200	175

Sources of Trips	
Trips diverted from the Auto Mode	1,600
Trips diverted from other Transit	430

Bus Ridership (all trip purposes included)

Station	*Inbound Boardings*
Fall River	265
New Bedford	285
Taunton	405
Raynham	60
Total	*1,015*

Air Quality Impacts (for the study area)
Daily estimates

Total VMT savings	98,790	Veh miles/day
CO Emission Reduction	691.93	Kg/day
NOx Emissions Reduction	98.69	Kg/day
VOC Emissions Reduction	56.01	Kg/day

Table 8: New Bedford / Fall River Commuter Rail Extension

Expanded Feasibility Study Update

ALTERNATIVE 3B (using DMU Vehicle Technology)
New Bedford/Fall River to S.Station (via the Stoughton Alignment)

Peak Headway=30min, Off Peak Headway=60 min, No: of trains per day=34 per branch
Oneway trip time= 1 hour and 25 min (from New Bedford), 1 hour and 27 min (from Fall River)
DMU s split and join at E. Taunton to serve both FR and NB
DMUs run express from N.Easton to Ruggles, N.Easton local stops @ Stoughton, Canton Jct, Rte128
Hyde Park, and Ruggles. Uses Weir Junction, with Dean Street Station instead of Taunton Center
Fare=$4.75, Free transfers to Subway in downtown

Year 2010 Demand Forecasts

Total Daily Inbound Person Trips from the study area to the Boston CBD/E.Cambridge

Commuter Rail Ridership (all trip purposes included)

Station	*Inbound Person Trips*	*Walk Access Trips*	*Drive Access Trips*	*Parking Demand Estimate*
Fall River	360	20	340	295
Freetown	240	0	240	210
New Bedford	380	25	355	310
East Taunton	1,100	0	1,100	960
Dean Street Station	400	10	390	340
Raynham	300	0	300	260
N.Easton	1,110	10	1,100	960
Total	3,890	65	3,825	3,335

Sources of Trips	
Trips diverted from the Auto Mode	2,915
Trips diverted from other Transit	975

Bus Ridership (all trip purposes included)

Station	*Inbound Boardings*
Fall River	110
New Bedford	210
Taunton	150
Raynham	
Total	*470*

Air Quality Impacts (for the study area)
Daily estimates

Total VMT savings	202,135	Veh miles/day
CO Emission Reduction	201.93	Kg/day
NOx Emissions Reduction	1415.75	Kg/day
VOC Emissions Reduction	114.61	Kg/day

Table 9: New Bedford / Fall River Commuter Rail Extension

Expanded Feasibility Study

ALTERNATIVE 4
Improved Express Bus Service

FallRiver to Boston: H=15 min (a new stop at Freetown)
Taunton to Boston: H=15 min (a new stop at Raynham)
New Bedford to Boston: H=15 min (two additional stops)
Free transfers from buses to the Subway system. Same fares as rail alternatives.
Every other bus from NB and FR would stop at S.Station and proceed to the Back Bay area
All buses would use the SE expressway HOV lanes
Park and Ride lots planned at Fall River, New Bedford, Freetown, E.Taunton, Taunton, Raynham and West Bridgewater

Year 2010 Demand Forecasts

Total Daily Inbound Person Trips from the study area to the Boston CBD/E.Cambridge

Bus Ridership (all trip purposes included)

Station	*Inbound Boardings*
West Bridgewater	115
Taunton	300
E.Taunton	600
Raynham	250
Easton	660
New Bedford	775
Fall River	500
Freetown	300
Total	***3,500***

Sources of Trips	
Trips diverted from the auto mode	1,790
Trips diverted from other transit	260
Bus trips already in the future No-Build	1,450

Air Quality Impacts (for the study area)
Daily estimates

Total VMT Savings	112,216	Veh miles/day
CO Emissions Reduction	785.96	Kg/day
NOx Emissions Reduction	112.10	Kg/day
VOC Emissions Reduction	63.63	Kg/day

Operations Simulation
May 1996

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

NEW BEDFORD/FALL RIVER COMMUTER RAIL EXTENSION PROJECT

OPERATIONS SIMULATION REPORT

Prepared by:

LS TRANSIT SYSTEMS, INC.

Submitted to:

VHB, Inc.

May, 1996

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
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D. Draft Amtrak 2010 Service Schedule

E. Amtrak Proposed High Speed Configuration, "Shore Line", South Attleboro to Boston

F. Vehicles and Vehicle Performance

G. ABB IC-3 DMU Performance Data

H. Assessment of Diesel Multiple Unit Trains for MBTA New Bedford/Fall River Commuter Service

EXECUTIVE SUMMARY

The MBTA intends to extend its successful network of commuter rail services to serve the Southeastern Massachusetts communities of Fall River and New Bedford. LS Transit Systems, Inc. (LSTS) has prepared this study to examine the operational feasibility and implications of accomplishing this extension by operating additional trains on the existing Northeast Corridor (NEC). At a point north of Attleboro Station a new junction will be constructed (the "Attleboro Bypass"), which would connect to Conrail's existing New Bedford Secondary extending to Taunton. The terminal stations of Fall River and New Bedford are each located on separate branch lines which diverge from the New Bedford Secondary at Myricks Junction, south of Taunton.

The New Bedford/Fall River Operations Simulation Report was developed to provide the MBTA with the greatest possible number of trains and service schedules for Years 2000 and 2010. The goal of this project was to determine the feasibility of achieving a level of service of 60 trains per day (with 15 minute peak intervals and 30 minute off-peak intervals from South Station to Taunton, in each direction) or 30 round-trips to New Bedford/Fall River along the NEC via the Attleboro Bypass. Based on the findings of this study, the planned level of service could not be supported on the NEC via the Attleboro Bypass junction.

Two operations simulation models were developed using RAILSIM®, LSTS' PC-based rail operations simulation software. The models incorporated the track, signal system, and facilities and equipment improvements expected to be in place by the Years 2000 and 2010. An analysis of the South Station area was not done as part of this project.

Initial simulations were performed for both single track and double track connections at Attleboro. Preliminary investigations indicated that a single track connection at Attleboro would not be operationally functional, due to the capacity and operation constraints. Therefore, the single track connection was removed from consideration early in the simulation development, with the double track connection remaining for further analysis.

The NEC east of Attleboro, excluding South Station, was found to have a capacity of 20 round-trip New Bedford/Fall River (NB/FR) trains in the Year 2000, with minor adjustments made to the existing MBTA schedule and with Amtrak's planned Year 2000 schedule in place.

Analysis of Year 2010 results found that adding trains to the MBTA's 2010 schedule for existing routes (as developed in the North South Rail Link Project) and satisfying Amtrak's 2010 schedule, a capacity of 44 trips per day would be achieved. This increase in capacity from Year 2000 is due, in part, to planned improvements to MBTA equipment performance and to the extension of a third track from Readville to west of the Route 128 Station.

Although a train capacity of up to 44 trains per day could be achieved by Year 2010, the MBTA's plan to provide 60 trains per day to Fall River and New Bedford could not be provided via the Northeast Corridor (NEC) with a junction at Attleboro.

1.0 PROJECT OVERVIEW

1.1 PROJECT HISTORY

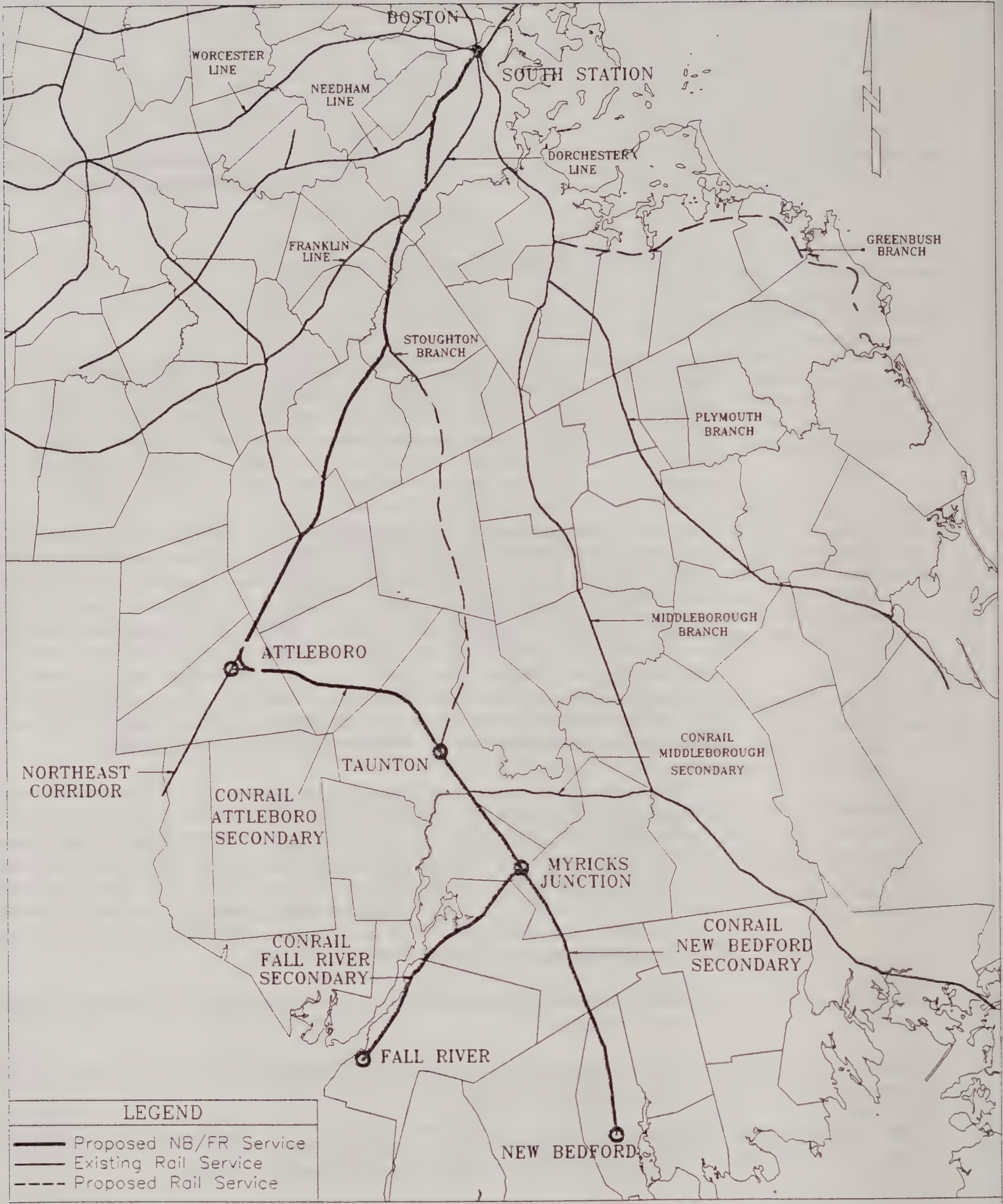
Until 1958, commuter rail service from South Station to New Bedford and Fall River, Massachusetts was provided by the New Haven Railroad along the Providence Railroad, via connections in Canton Junction and Taunton. In September 1958, New Bedford and Fall River trains were cut back as part of the New Haven's elimination of the Old Colony service. Rail service is currently provided only as far as Stoughton along the same line, now known as the MBTA's Stoughton Branch.

In the last decade, interest in renewing service to Fall River and New Bedford has increased. Toward this goal, the Massachusetts Bay Transportation Authority (MBTA) commissioned a feasibility study of commuter rail service to New Bedford and Fall River. This study, *Commuter Rail Extension Feasibility Study - New Bedford/Fall River,* was completed in January, 1990 by Louis Berger Associates. The recommendation of this study was that MBTA service on the Stoughton Branch be extended to New Bedford and Fall River. For this study, five rail extension alternatives to New Bedford and Fall River were studied. The study area included the on-line cities and towns of Stoughton, Easton, Raynham, Taunton, Berkeley, Lakeville, Freetown, New Bedford, Fall River, Dartmouth and Westport.

In February, 1991, the Joint Transportation Planning Group (JTPG) of Southeastern Massachusetts Metropolitan Planning Organization reviewed and presented a position statement on the 1990 Feasibility Study. The JTPG raised several issues related to alternative transportation strategies. To address these issues, the *New Bedford/Fall River Commuter Rail - Expanded Feasibility Study - Draft Report* was prepared by the MBTA in cooperation with the Central Transportation Planning Staff (CTPS). The draft report was completed in May, 1995 and included the following rail alternatives for consideration:

- Four options extending the Old Colony Middleborough Line to either Fall River or New Bedford,
- Two options extending the Stoughton Branch to either North Easton or Fall River and New Bedford,
- One option branching from the Northeast Corridor Main Line (NEC) in Attleboro to Fall River and New Bedford through Taunton.

Based on the findings of the MBTA Expanded Feasibility Study, state funds were set aside to further study a commuter rail extension to New Bedford and Fall River. LS Transit Systems, Inc. (LSTS), as a subconsultant to Vanasse Hangen Brustlin, Inc. (VHB), has provided an operational analysis for this study. The focus of this report



NEW BEDFORD/FALL RIVER COMMUTER RAIL EXTENSION PROJECT
NORTHEAST CORRIDOR VIA ATTLEBORO BYPASS
FIGURE 1

is on the operational analysis of service via the Northeast Corridor (NEC) and the Attleboro Bypass to Fall River and New Bedford through Taunton.

1.2 PROJECT DESCRIPTION

The MBTA intends to extend its successful network of commuter rail services to serve the extreme southeastern Massachusetts communities of Fall River and New Bedford. This study examines the operational feasibility and implications of accomplishing this by operating additional trains on the existing Northeast Corridor (NEC) between South Station, Boston and a point between Mansfield and Attleboro. North of Attleboro Station a new junction would then be constructed to a new connecting track or tracks (the "Attleboro Bypass") which would then connect to Conrail's existing New Bedford Secondary giving access to Taunton and continuing to Fall River and New Bedford. The terminal stations of Fall River and New Bedford are each located on separate branch lines which diverge at Myricks Junction. Figure 1 displays the rail corridor for the study area.

Previous studies have shown that the Attleboro Bypass route would utilize existing right-of-way owned by the MBTA, EOTC, and Conrail and would require various levels of track upgrading along existing and abandoned lines. Some acquisition of property would be required to accommodate connection between the existing lines, station siting and layover facilities. Bridges, culverts, grade crossings, sidings and signals and communications will require improvements to comply with MBTA standards and level of service requirements.

This report was developed to determine the operational feasibility of the MBTA's planned level of service for trains and service schedules in Design Years 2000 and 2010. The goal of the study was to determine the feasibility of achieving the level of service of 60 trains per day (with 15 minute peak intervals and 30 minute off-peak intervals, in each direction) to New Bedford/Fall River along the NEC via the Attleboro Bypass. This report details the assumptions, methodologies and results of this analysis.

Using data such as the proposed railroad operations along the New Bedford/Fall River extension, in conjunction with a knowledge of the study area, several operations simulation models were developed using RAILSIM®, LSTS's PC-based rail operations simulation software. The models incorporated the track and signal system, and facilities and equipment improvements expected to be in place by the Years 2000 and 2010.

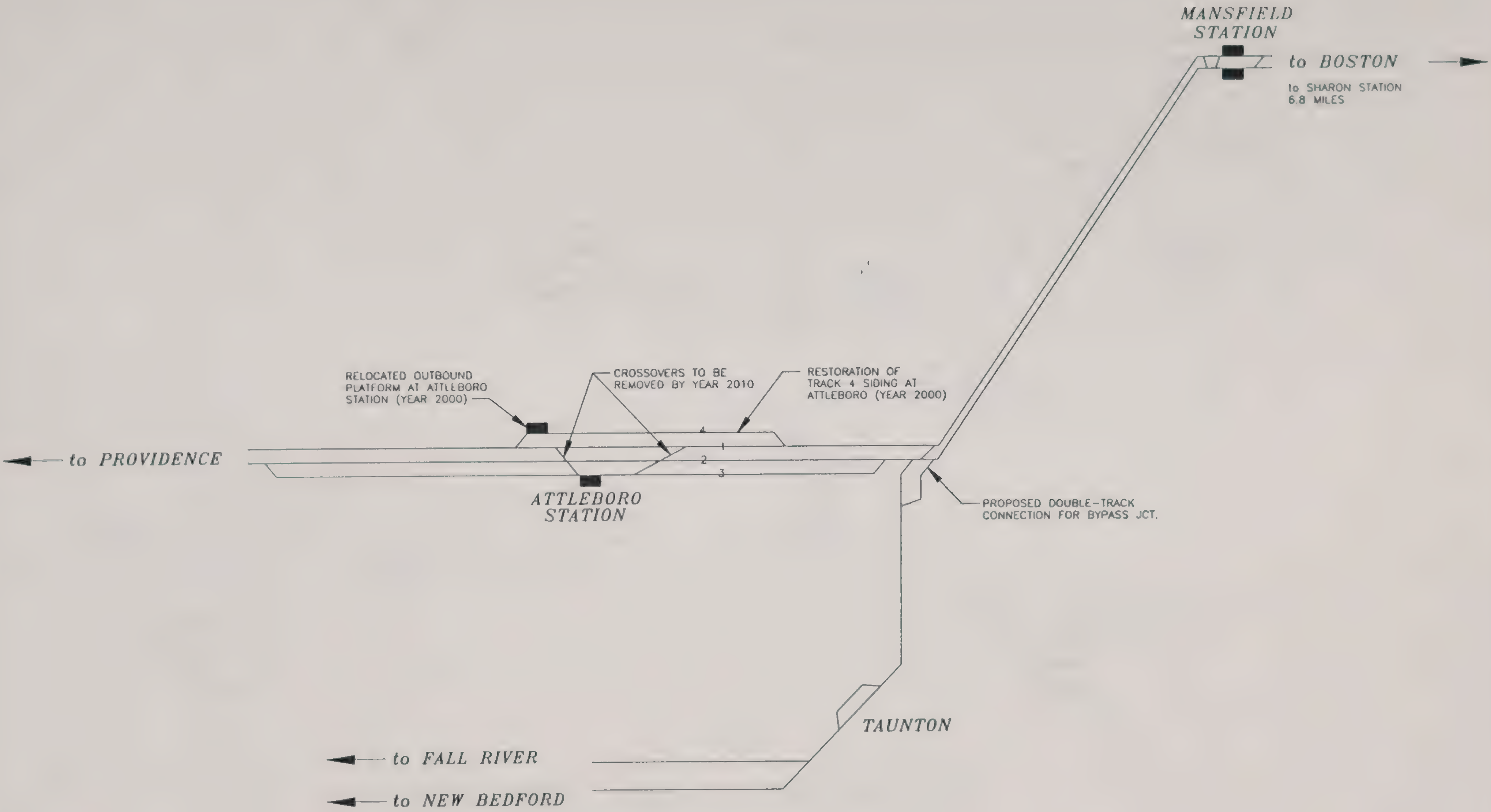
Early analyses were conducted for both single track and double track connections at Attleboro. Preliminary investigations indicated that a single track connection at Attleboro would not be operationally functional. Therefore, the single track connection was removed from consideration early in the simulation development, with the double track connection remaining for further analysis.

Utilizing a double track junction with the NEC and peak-period Amtrak and MBTA New Bedford/Fall River extension schedules, two models were simulated, analyzed and optimized for Years 2000 and 2010. These models were developed so as not to negatively impact NEC operations. Figures 2, 3 and 4 provide schematic diagrams of the simulated track configurations.

Included in development of the models were Year 2000 and 2010 peak-period simulated schedules for New Bedford/Fall River extension service on the NEC, which included Amtrak, MBTA and freight services. "Choke" points along the NEC between the Attleboro junction and Readville that limit the ability to develop a satisfactory schedule were identified and refined for input into the simulation models.

The contents of this report contain LSTS' findings for extending MBTA commuter service to Fall River and New Bedford via the NEC and Attleboro corridor in the Years 2000 and 2010. Additionally, an evaluation of the impacts and benefits of using Diesel Multiple Units (DMU's) on the New Bedford/Fall River extension for Years 2000 and 2010 has also been included.

NORTHEAST CORRIDOR
ATTLEBORO to MANSFIELD
SIMULATION TRACK LAYOUT(S)


MANSFIELD STATION
to BOSTON
to SHARON STATION 6.8 MILES
RELOCATED OUTBOUND PLATFORM AT ATTLEBORO STATION (YEAR 2000)
CROSSOVERS TO BE REMOVED BY YEAR 2010
RESTORATION OF TRACK 4 SIDING AT ATTLEBORO (YEAR 2000)
4
1
2
3
to PROVIDENCE
ATTLEBORO STATION
PROPOSED DOUBLE-TRACK CONNECTION FOR BYPASS JCT.
TAUNTON
to FALL RIVER
to NEW BEDFORD

LS Transit Systems

Figure 2

NORTHEAST CORRIDOR
SHARON to ROUTE 128
SIMULATION TRACK LAYOUT(S)

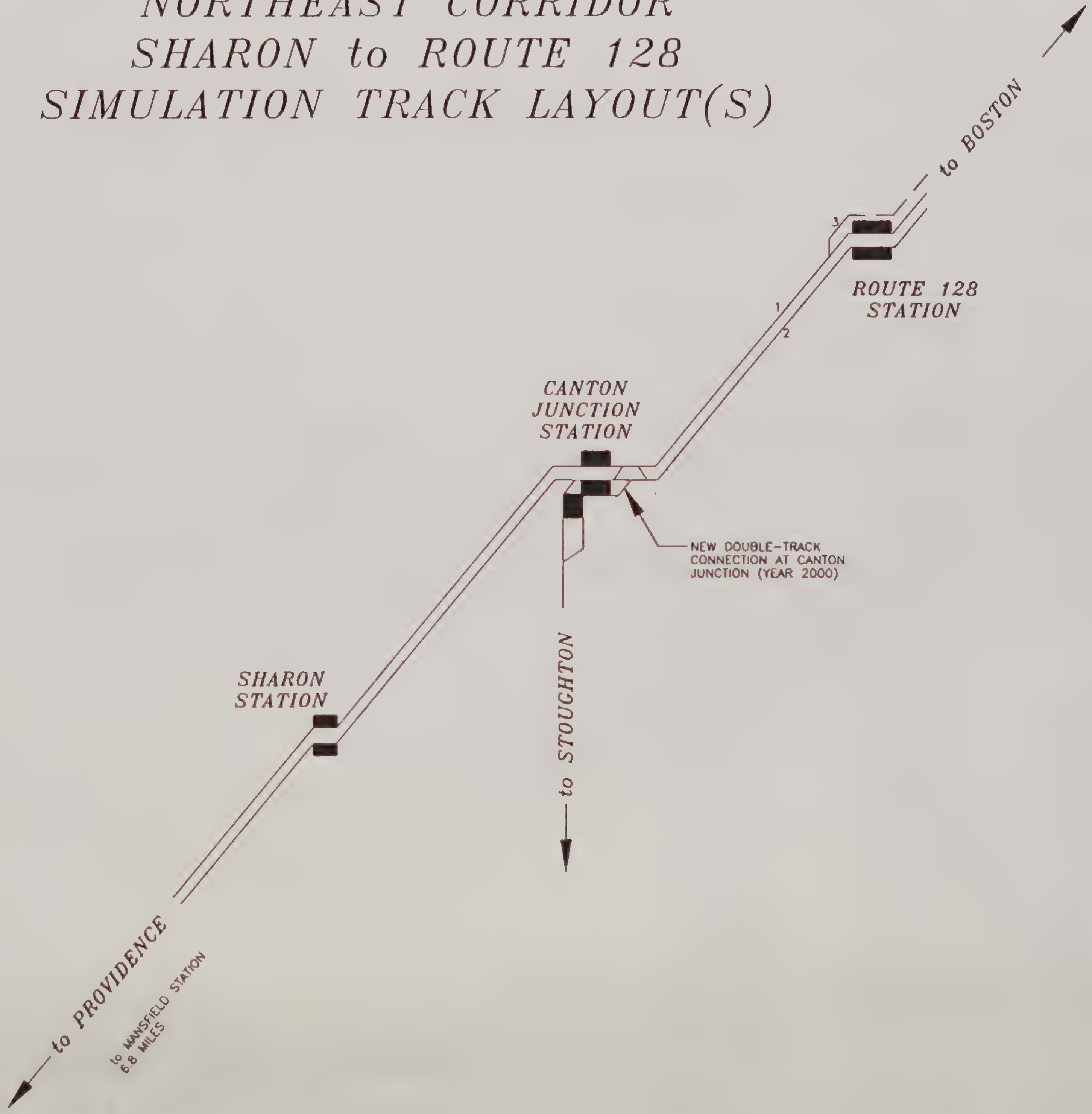


Figure 3

NORTHEAST CORRIDOR
ROUTE 128 to BACK BAY
SIMULATION TRACK LAYOUT(S)

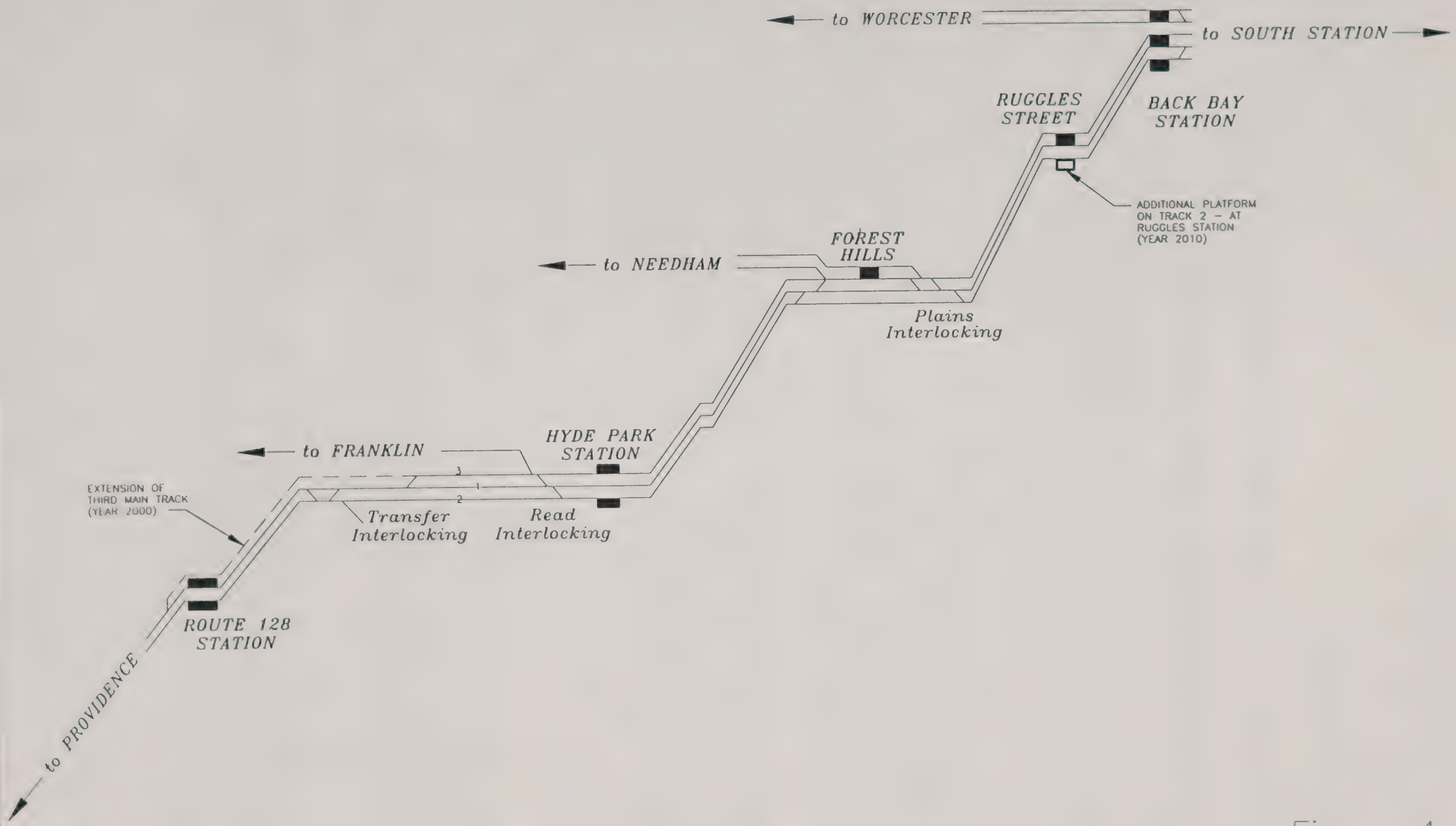


Figure 4

LS Transit Systems

2.0 SIMULATION METHODOLOGY

2.1 DEVELOPMENT OF YEAR 2000 SIMULATION MODEL

A simulation model of the projected physical plant and signal system configuration in the Year 2000 was developed using RAILSIM®. The starting point for this effort was an existing RAILSIM® database that had been developed for the MBTA and the North South Rail Link Project as a separate assignment. The limits of the simulation model extend from Providence, RI to South Station, Boston on the Northeast Corridor (NEC) and include the Franklin Branch east of Walpole; the current Stoughton Branch; the entire Dorchester Branch; the Needham Branch east of West Roxbury and a small portion of the Worcester Line from Beacon Park Yard (Allston) to the junction with the NEC at Back Bay (Cove Interlocking).

The pre-existing RAILSIM® model was extensively modified to reflect planned and approved capital projects, including rolling stock acquisition by Amtrak, that are expected to be completed by Year 2000. These planned changes are assumptions used in the model development and are discussed in greater detail later in this report.

Train operations for the Year 2000 simulation presented a particular challenge, requiring LSTS to develop a substantially new MBTA commuter rail service plan. The new MBTA service plan was developed based on the time "slots" available after projected Amtrak services had been assigned. This methodology was necessary because an MBTA South Side service plan for Year 2000 was not available at the time of this study. The existing MBTA schedules are not compatible with Amtrak's high-speed Year 2000 service plan. Development of a new MBTA service plan was done by starting with Amtrak's projected 1999-2000 timetable, Providence to Boston, and adjusting MBTA services to emulate existing (1996) service levels without interfering with Amtrak operations. Minor time changes from one to ten minutes were made to existing MBTA commuter rail schedules to provide adequate train separation to optimize throughput. When New Bedford/Fall River services were included, additional adjustments of up to five minutes were sometimes necessary, and stopping patterns were changed as required.

Suitable operating "slots" for New Bedford/Fall River (NB/FR) train services were identified after Amtrak and "existing" MBTA services (baseline services) were operating smoothly. The NB/FR trains were then examined for their delay impact on baseline services. Minor adjustments were made as necessary. When all services were applied to the simulation model, the on-time performance at key stations was then computed. These four key stations were: Route 128 in the eastward direction, Canton Junction (on the Stoughton Branch), the Attleboro Bypass/NEC junction, and Providence in the westward direction. Since Amtrak does not serve any station between Route 128 and Providence, Amtrak westbound performance was measured only at Providence. Summary tables of on-time performance were generated for each measurement location, for the 6:00 AM to 10:00 AM morning peak and for the 4:00 PM to 8:00 PM evening peak.

In addition to lateness statistics at identified stations, signal delay minutes were generated for the evening peak period. A signal delay minute is accrued when a train is slowed or stopped by signal indication (and/or cab signal code) for one minute. A signal delay minute does not represent the actual train delay. For example, a train may accrue a 20 minute signal delay by operating on an Advance Approach indication for twelve minutes and then eight minutes on an Approach indication. This does not, however, mean that the train is 20 minutes late. A signal delay indicates that a train will not operate on clear signals for a specified period of time.

After collecting signal delay totals for the full schedule, the NB/FR trains were eliminated. Without making any other changes, the simulation was run again to compute signal delay minutes *without* the NB/FR trains. This generates a delta that can be attributed entirely to the addition of NB/FR trains and gives an indication of the "stress" on system capacity due to these additions. Signal delays are a reliable indication of delays caused by conflicting traffic. A perfectly designed and executed operating plan with consistent headways and no conflicts at interlockings (such as junctions) would exhibit zero signal delay.

A delay simulated analysis was performed on each simulation model with full train services to evaluate the stability of the schedule under realistic conditions. Delay simulation mimics real-world terminal departure and intermediate dwell delays. Large changes in on-time performance and signal delay minutes indicate a fragile operational plan that would potentially have difficulty overcoming minor changes. On-time performance at stations is another way to measure the impact of random delays.

2.1.1 Single-Track Attleboro Bypass

The Attleboro Bypass, as proposed, is an entirely new section of railroad on a new right-of-way that would enable westbound trains from Boston to operate directly from the Northeast Corridor to the existing New Bedford Secondary and thence to Taunton and Fall River or New Bedford, without entering Attleboro Station to reverse direction. Presently, only eastbound trains from Providence can enter the New Bedford Secondary as a continuous move. Amtrak's seasonal *Cape Codder* is operated in this fashion.

The Attleboro Bypass was modeled by installing a new high-speed (#32) crossover between NEC Tracks 1 and 2 east of existing Holden Interlocking and by installing an additional turnout on Track 2. A single-track Attleboro Bypass involves one track connecting to the NEC, in addition to the crossover between Tracks 1 and 2. This configuration would not allow for trains traveling in opposite directions to meet along the Bypass. The single-track Bypass was modeled by modifying VHB's 10% double-track alignment design. Simulations were then modeled to take into account the run times necessary for conflicting trains to travel between Bypass junction and Taunton.

Early analyses were conducted for single track connections at Attleboro. Preliminary investigations indicated that a single track connection at Attleboro would not be operationally functional. Therefore, the single track connection was removed from consideration early in the simulation development, with the double track connection remaining for further analysis.

2.1.2 Double-Track Attleboro Bypass

The double-track version of the Attleboro Bypass conceptual design provides for two diverging turnouts from NEC Track 2 to the two tracks of the Attleboro Bypass. The Bypass as presently conceived would not be continuously double-tracked. The double-track Bypass design was modeled by providing a #20 turnout at the west end of the double-track section, approximately 1,400 feet west of the NEC junction. A westbound train leaving the NEC and encountering an opposing train that had left Taunton Station would wait for the opposing train at this double-tracked section.

The double-track Bypass concept is useful in that it will allow a late westbound train to exit the NEC without forcing an opposing New Bedford/Fall River train to wait at Taunton.

2.2 DEVELOPMENT OF YEAR 2010 SIMULATION MODEL

The Year 2010 simulation model built upon the Year 2000 model. Additional capital and equipment performance improvements were identified and modeled as:

- The east switch (turnout) of Track 4 at Attleboro (Holden Interlocking) was upgraded from the present #15 (30 mph merging speed) to #32 (80 mph merging speed), and use of Thatcher Interlocking was discontinued;

- High-level platform access to all three main tracks at Ruggles Station was assumed; this is a very simple simulator change that identifies a platform location on Track 2 whereas previously (and presently) this does not exist;

- Crossovers and turnouts to the Franklin Branch at Readville were upgraded to #20, enabling a 45 mph diverging speed instead of the present 30 mph;

- Deadheading MBTA trains between Providence and East Junction in Attleboro were eliminated, assuming a new layover facility to be constructed near Providence Station. The deadhead trains were simply deactivated from the simulator database;

MBTA train performance was modeled to match Amtrak Metroliner standards by upgrading to a 100 mph top speed (MAS) and by substituting a proven acceleration and braking performance profile.

Performance evaluation methodology was as previously described.

2.2.1 Single-Track Attleboro Bypass

The Year 2010 single-track Attleboro Bypass model incorporated the same track and signal system as the Year 2000 single-track model, with the addition of the five major items mentioned above. There is no difference in the track and signal system of the Bypass or the Bypass junction with the NEC between the 2000 and 2010 models for the single-track Bypass configuration. As stated in Year 2000 methodology, the single track connection could not be supported. Therefore, the single track option was dropped from consideration early in this study.

2.2.2 Double-Track Attleboro Bypass

The double-track Attleboro Bypass incorporated the same track and signal system as the Year 2000 double-track model, with the exception of the major items mentioned above that affect other parts of the railroad. There is no difference in the track and signal system or the Bypass junction with the NEC between the 2000 and 2010 models for the double-track Bypass configuration.

2.3 SOURCES OF SIMULATION DATA

The following source documents were utilized to develop and refine the RAILSIM® simulation models. This list is not all-inclusive; additional sources of information, including input from Amtrak, the MBTA and other LSTS employees, contributed information and advice to the models.

- Amtrak Northeast Corridor Employees Timetable No. 2 Effective 12:01 AM EST Sunday, October 29, 1995

- Amtrak MBTA Employees Timetable, May, 1995

- Amtrak "Proposed High Speed Configuration, 'Shore Line' New Haven to Boston", January 1, 1996

- Letter, Michael J. O'Malley, Transportation Officer, Massachusetts Bay Transportation Authority, to Michael J. Carragher, P.E., LS Transit Systems, Inc., October 17, 1995 (describing planned MBTA service levels, existing lines, 1998 through 2010)

- Nine-Aspect Cab Signal System, Signal Control Line drawings for the Northeast High-speed Rail Improvement Project, New Haven to Boston; Amtrak P.I., LS Transit Systems

- Amtrak "Thatcher, Boro, Holden Interlockings, Signal Aspects," October 6, 1993

- Amtrak "Mansfield Interlocking, Signal Aspects," July 25, 1994

- Amtrak "Junction Interlocking, Signal Aspects," July 25, 1994 (Canton Junction)

- Amtrak "Transfer, Read Interlockings, Signal Aspects," December 9, 1993

- "Mansfield Interlocking, Westward Aspects," LSTS, October 16, 1995

- "Mansfield Interlocking, Eastward Aspects," LSTS, October 16, 1995

- List of (planned) civil speed restrictions, New Haven to Boston, Northeast High-speed Rail Improvement Project, for Amtrak "high-speed" operations, as of 1/96

- List of (planned) civil speed restrictions, New Haven to Boston, Northeast High-speed Rail Improvement Project, for Amtrak "conventional" operations, as of 1/96

- Amtrak "Draft Amtrak 2010 Service", Boston to New York ("For Planning Purposes Only"), as of 1/96

- Shore Line and Attleboro Bypass plans, 10% submittal, VHB Team, 11/95

- ABB Corporation, "IC3 Performance Data", with acceleration and braking curves, circa December 1993

A wide variety of additional documents and people were also consulted. Examples include in-progress design by LS Transit Systems of a new north-side platform configuration and location for Attleboro Station, the new configuration of Mansfield Station, construction of Tracks 12 and 13 at South Station, conceptual changes affection Route 128 Station and conceptual variations of the Attleboro Bypass.

2.4 RAILSIM® SIMULATION DATA CALIBRATION

Calibration of a simulation model requires observing actual railroad operations and collecting signal clearing times (time required for an Automatic Block Signal or Cab Signal code rate to restore to Clear or best aspect after the passage of a train) at selected locations, and riding selected trains to collect point-to-point running time data samples. Obviously, this is not possible for simulations of future operations, particularly involving massive track and signal system changes that are not yet in service in the field, and new types of equipment that cannot be observed, even on other properties. However, the original RAILSIM® model developed for the MBTA that simulates existing (1995) Amtrak and MBTA operations can be, and was, calibrated to actual rolling stock and signal system performance. The results were published in Technical Report No. 6 of the North-South Rail Link Project, *"Commuter Rail RAILSIM® Simulation Report"* (February, 1996).

The calibration effort involved random sampling of field data, including station dwell times, as described above. Simulator output was compared with the field data. A threshold of a ten percent discrepancy between field and simulation data is generally considered conclusive of a good correlation between field and simulated operations. Field operations are subject to numerous, often uncontrollable human, mechanical and environmental factors such as individual locomotive engineer performance, dwell times at stations, time of day and passenger loading. Weather affects starting and stopping abilities in much the same way that it can affect the performance of motor vehicles. An attempt was made to compensate for this by noting the weather and any unusual conditions when observers were in the field, and by making multiple observations at the same location or on the same type of train (e.g., two off-peak and one peak round-trip between Boston and Providence). Results can then be averaged.

The baseline simulation model used as the starting point for the New Bedford/Fall River simulation effort was successfully calibrated to existing MBTA and Amtrak operations. In the case of Amtrak trains, substantial experience from other, unrelated simulation assignments involving other parts of the Amtrak network -- notably the Northeast Corridor between New York and Washington -- has led to the development and refinement of highly accurate modeling of Amtrak diesel-hauled and electric-hauled trains of various consists. This expertise has lent itself to the New Bedford/Fall River analysis.

3.0 OPERATING AND DESIGN ISSUES

Numerous ancillary issues and concerns were addressed at the outset of the project or became apparent during the development of the simulation models. Many are related to a global view of how the railroad between Providence and Boston and its various branches will be operated in the future, and what the ramifications are of decisions that have already been made by design and by default and are now, or will be, considered fixed constraints. Each of the major items so identified is discussed in the subsections that follow.

3.1 OPERATIONS AND CAPACITY AT SOUTH STATION

It is acknowledged by many experts on Boston's rail network that the capacity of South Station and its support facilities will be increasingly taxed in the near future, absent construction of the proposed Rail Link under downtown Boston. The simulation models prepared for the New Bedford/Fall River study include a virtually complete complement of revenue train operations into and out of South Station, with the notable exceptions being that MBTA Old Colony services, and Amtrak services on the Boston & Albany route, were not included. Tracks 12 and 13 were reserved for the exclusive use of Old Colony trains. A full analysis for the South Station area was not done as part of this project.

3.2 CAPACITY CONCERNS IDENTIFIED BY AMTRAK

Prior to the study and its RAILSIM® simulation model development, the National Railroad Passenger Corporation, (Amtrak), identified several infrastructure improvements on the basis of its own preliminary analysis. Amtrak has identified several improvements that are required to support the operation of services to New Bedford/Fall River via Attleboro. Amtrak claims that at the time it developed its plans for high-speed electrified train service from New York to Boston, including the electrification of the line between New Haven and Boston, it was unaware that MBTA trains to New Bedford/Fall River might be operated on the Corridor west of Canton Junction.

Amtrak's concerns regarding track and signal capacity, as summarized and communicated to the Commonwealth of Massachusetts, were:

- A double-track Attleboro Bypass connection will be necessary to avoid "congestion at the bypass interface", which Amtrak predicts would occur if the Bypass were to be constructed as a single track;

- Potential capacity constraints in Sharon between Milepost 207.8 and 211, after Year 2005. Amtrak stated that construction of a passing siding will be necessary at

Sharon by the Year 2000 if New Bedford/Fall River service is established via this route;

- The need to extend existing Track 3 from Readville to Route 128 Station or construction of a passing siding in the vicinity of Mansfield Station (Milepost 204);
- Severe traffic congestion predicted during peak periods along the heavily-used Forest/Plains to Back Bay section, locally known as the "Southwest Corridor". Amtrak believes that additional modifications to the proposed signal system may be necessary to accommodate the increase in rail traffic that a new New Bedford/Fall River service would represent.

Amtrak's concerns were considered throughout the development of the RAILSIM® simulation models. All of the issues listed above were addressed in this study. While these issues do not steer the report, they were taken into consideration in the analysis.

3.3 CAPACITY IMPLICATIONS OF HIGH SPEED TRAINS

Signal design speeds are based on a combination of many factors, some quantifiable others that are strictly operational. Amtrak's plan for the Northeast Corridor is to provide a high-speed service between New York (Penn Station) and Boston (South Station). This project will bring Amtrak's Maximum Authorized Speed (MAS) up to one hundred and fifty miles per hour, thereby making it possible to provide a three hour trip time for this service.

To accomplish this level of service Amtrak will be electrifying its operations between New Haven and Boston. During the early stages of this study, a two track and one track interface at the Attleboro Bypass was investigated. The study showed that a two track junction was absolutely necessary, for movement off of and onto the Attleboro Secondary. The operations at this junction are critical to the success of NB/FR trains entering the Corridor. It may be wise for the MBTA to request Amtrak to extend the electrification down the Attleboro Secondary for a distance of one mile. Should the MBTA opt for Dual-Mode locomotives for the head power for the NB/FR service, a change of power should be done on the branch not the corridor. Should a NB/FR train stall or become disabled, extensive delays to Amtrak's service and the MBTA Providence Line would occur.

Signaling for a one hundred and fifty miles per hour track will stretch out the signal block distances required to provide for safe braking distance. While high speeds are attractive to a system, developmental concerns would result. Because MBTA trains can not achieve this level of operation, run times will increase and capacity on the system will decrease. Operating trains at a lower speed than that which the track is signaled for will decrease capacity and increase running times.

The definition of capacity is the amount of trains that can be successfully placed between two given points. The result of the combination of speed and capacity is called "throughput". Throughput is the number of trains capable of running between two given points with clear signals in a specified time. Signaling speeds are designed to achieve this by factoring in the following:

- Equipment - Operational Characteristics
- Civil - Curves, Elevation, Municipalities Law
- Operational - Level of Service Required (consists size, frequency)

Throughput is a major concern of the MBTA's for trains operating on the Northeast Corridor (NEC) in Years 2000 and 2010. In the future, the NEC will be optimized for high-speed trains. Because MBTA equipment and operations will differ from Amtrak's future plans, throughput of MBTA trains will actually decrease from what it is today.

Currently, the Northeast Corridor, between Boston and Providence, is optimized for a MAS of 100 mph. This means that the difference between Amtrak's and the MBTA's equipment and operations is less today than for future operations. Current signal and block design also better supports the MBTA existing operational needs. This study concludes that the proposed Year 2000 high-speed Amtrak service will adversely affect the MBTA until Year 2010 when equipment and operations will be more compatible.

The MBTA is currently considering many types of equipment to run on the corridor for the proposed NB/FR service, including Diesel Multiple Units. The MBTA needs to close operational gaps Amtrak has created with their new high-speed trainsets. Acceleration, braking characteristics, and automatic train control (ATC) should ideally match that of Amtrak's high-speed trains, and, at the very least, improve upon the current equipment the MBTA is using.

The following table includes a summary of the types of equipment and operating characteristics for existing conditions, Year 2000 and Year 2010.

NEC Operations

Year	*MBTA Trains*	*NB/FR Trains*	Amtrak Trains	*MBTA MAS*	Amtrak MAS	*MBTA Power*	Amtrak Power
1996	*102*	-	18	*80 MPH*	100 MPH	*Diesel*	Diesel
2000	*102*	*40*	34	*80 MPH*	150 MPH	*Diesel*	Electric
2010	*122*	*44*	52	*100 MPH*	150 MPH	*Diesel* *Electric*	Electric

3.4 PROVIDING FOR SERVICE HEADWAYS TO BRANCH ROUTES

MBTA's stated goal is to provide 30 minute peak period, peak direction service to Fall River and to New Bedford -- each of which is the terminus of a separate branch line. To provide this level of service and still offer a one-seat ride to and from Boston dictates that the service be configured one of three ways (or a combination):

- the service headway of New Bedford/Fall River trains on the Corridor will be twice the target branchline headway -- or 15 minutes in the peak direction during peak periods;
- train consists will be joined eastbound and separated westbound at Taunton;
- cross-platform changes will be made at Taunton for passengers who wish to travel to or from branchline stations not being served by a through train.

The latter option need not dictate that patrons on the Fall River Branch, or the New Bedford Branch, would exclusively get one-seat service. The pattern could be alternated or designed to reflect demand.

It was clear at the outset that 15 minute headways of New Bedford/Fall River trains on the Corridor was impossible to achieve. The problem becomes more complex by; the inauguration of high-speed Amtrak trains scheduled for Year 2000, Amtrak's MAS of 150 mph, and the MBTA's MAS of 80 mph until the appearance of higher performance MBTA locomotives sometime between Years 2000 and 2010.

Providing for adequate service headways on branch lines is an old and familiar problem. Numerous domestic examples exist of successful cross-platform changes, including on the Long Island Railroad at Jamaica Station, on Metro-North at Stamford, Connecticut (a "drop-back" arrangement), Metro-North at Brewster-North on the Harlem Line, and a small New Jersey Transit operation between Princeton Junction and Princeton.

3.5 LIMITATIONS OF SINGLE-TRACK BYPASS

A single-track Attleboro Bypass would preclude the possibility of meets between opposing trains between Mansfield and Taunton. It is possible to design the service such that a meet would not normally be required, although this may be at the expense of the target peak period headway. However, in practice, any service design can become subject to unplanned delays. If a westbound New Bedford/Fall River train was to meet its opposite number eastbound from New Bedford/Fall River, the meeting would have to take place either at Taunton or on the NEC at Mansfield. The latter is unacceptable during peak periods, the result to following trains would be delays with a rippling effect. If the meets were scheduled at Taunton, the eastbound train would be delayed approximately 15 minutes, until the westbound train cleared.

3.6 MAXIMUM DIVERGING SPEED AT ATTLEBORO BYPASS

The preliminary design of the Attleboro Bypass junction with the Northeast Corridor is intended to support an 80 mph diverging move. This is to enable westbound trains to exit the NEC as quickly as possible, thereby minimizing delays to following trains. Simply, for any given maximum operating speed of a following train, the faster diverging speed will enable a following train to operate on a shorter headway without experiencing signal delay due to the diverging train ahead, which is slowing down in order to make the diverging move.

Lower diverging moves would reduce the cost of the proposed junction. Standard (#20) turnouts are less costly to install and maintain than #32 turnouts, which are required to support 80 mph operation. A quantitative analysis of the impact on train operations due to lower speed crossovers was beyond the scope of this study. The maximum authorized speed on Tracks 1 and 2 in the vicinity of the proposed Attleboro Bypass/NEC junction is presently 100 mph. Slow diverging speeds would not be consistent with these high NEC speeds, even without Amtrak's planned improvements.

For the purposes of this study, operating speeds on the Attleboro Secondary were assumed to be 59 mph. As further information becomes available, revisions to this constraint may be required.

3.7 EQUIPMENT LAYOVER AND BALANCING

Equipment layover and balancing was not taken into account. This would involve timetable refinement which is beyond the scope of the study. However, an attempt was made to develop New Bedford/Fall River service patterns which included approximately the same number of trips in each direction.

4.0 ASSUMPTIONS, YEAR 2000

4.1 ELECTRIFICATION, NEW HAVEN TO BOSTON

A critical assumption is that electrification of the existing Northeast Corridor between New Haven and Boston will be completed prior to the Year 2000. It is further assumed that the electrification will go on-line as scheduled and that Amtrak will have sufficient electric locomotives and electrified high speed trainsets for all of its revenue services between New York and Boston. If this does not occur, or if the project is significantly delayed, the operation of the railroad will be different than that assumed for this study.

4.2 AMTRAK AND MBTA SERVICE AND EQUIPMENT

It is understood that the MBTA will not convert to electric motive power by Year 2000. MBTA train performance (acceleration and braking) was therefore maintained at present standards for the Year 2000 simulation.

The backbone of MBTA motive power in Year 2000 is expected to continue to be the F40PH-2C diesel-electric locomotive, likely augmented with additional new or remanufactured units of similar performance. Bi-level coaches of the type recently supplied by Kawasaki have generally been successful and it is clear that the trend will be toward a larger fleet of cars of this type, with each train nominally consisting of seven bi-level cars and one locomotive, operating in push-pull mode. Potential changes to operating and train consist practices due to early-1996 Federal Emergency Orders have not been taken into consideration for this study. Long-range changes to current push-pull operating practices have not been established by the Federal Railroad Association (FRA), so cannot be assumed for this study.

MBTA plans at least one additional peak-direction, peak period train per route by Year 2000. This was incorporated at a level equal to MBTA's target wherever possible. Reverse-peak service was not necessarily improved (due to capacity constraints) and issues concerning equipment availability and balancing were not addressed.

Amtrak "conventional" trains are to be powered by electric locomotives by the year 2000. It was assumed that the performance of these trains will be similar to that of the "Metroliner" trains presently operating between New York and Washington. Typically, these services consist of a single 7,000 h.p. AEM-7 B-B electric locomotive and four to six Amfleet cars. Amtrak high-speed trainsets, now on order from Bombardier, are expected to be ready to enter service by the Year 2000. These trainsets will be capable of speeds up to 150 mph. Amtrak has already identified which train schedules will be assigned high-speed trainsets. Those remaining will be assigned "conventional" equipment. Amtrak plans 34 trains (theoretically 17 round-trips) , including both high-speed and conventional speed trains, between New York and Boston by the Year 2000.

Amtrak has identified time slots for service in Year 2000 through Year 2010. Amtrak's time slots were fixed and the MBTA's existing (1996) schedules were adjusted to permit reliable operation of the new Amtrak trains. Amtrak services were maintained at 100% on-time performance in the ideal operations simulations, except when delays were due to inadequate schedule time. Inadequate schedule time means that the train(s) cannot maintain schedule because there is not enough time allowed in the schedule for the train to maintain on-time performance, even under ideal conditions.

Many time slots to be utilized by Amtrak by Year 2010 will remain "vacant" in Year 2000. However, applying new MBTA services in Year 2000 only to be forced to withdraw them in Year 2010 does not seem to be wise operating philosophy. Therefore future Amtrak operating slots were protected. Some adjustments to MBTA schedules occurred anyway because of improved MBTA train performance expected by Year 2010.

4.3 TRACK AND SIGNAL IMPROVEMENTS AT ATTLEBORO

Separated from the Attleboro Bypass, improvement of Hebronville Interlocking is planned. Hebronville Interlocking is located between Mileposts 193 and 194 west of Attleboro Station. The turnout to NEC Track 4, passing siding and running track, is to be upgraded from the present #15 turnout to a #32, thereby improving diverging speed to 80 mph. This improvement has been incorporated in the simulation database. The intent of this improvement is to enable a quicker diverging move off the NEC Track 2 into Attleboro Station. The present and proposed Attleboro Station does not have platform access from Track 2; therefore, it is necessary to support eastbound trains from Providence to the platform at Attleboro Station.

Presently, Track 4, in this area, has a maximum authorized speed (MAS) of 60 mph, except for the curve near Milepost 195.0, where there is a civil restriction of 30 mph. It was assumed as part of Amtrak's high-speed project that this speed restriction would be eliminated and the speeds raised to 60 mph. This seems to be a logical assumption, due to the fact that the effectiveness of the high-speed turnout would be compromised by trains still having to reduce their speeds for this curve.

In addition to the upgrade of the inbound Track 3 siding at Attleboro, the Track 4 siding in the outbound direction will be restored. A #32 turnout at the east end will be installed for 80 mph diverging moves, while a #20 turnout at the west end of the siding will permit 45 mph speeds as trains accelerate from Attleboro Station. As part of the reinstallation of this siding, the outbound Attleboro Station platform will be relocated to Track 4 from Track 2, and in common with all MBTA stations on the NEC by Year 2010, will be rebuilt as high-level.

4.4 TRACK AND SIGNAL IMPROVEMENTS AT CANTON JUNCTION

Canton Junction presently consists of a #8 turnout located on NEC Track 2 to diverge to the Stoughton Branch. This means that westbound trains must first cross over Track 1 to Track 2 via a #20 crossover before diverging onto the Stoughton Branch. This turnout limits speed to 15 mph. This is inconsistent with present MBTA train operations and is magnified when high-speed Amtrak service begins on the NEC. A 15 mph diverging move to the Stoughton Branch will create a bottleneck at this junction and will cause a ripple-effect up and down the corridor.

The MBTA and Amtrak have agreed to reconstruct this interlocking with two #20 turnouts and a reconfigured double-tracked junction. This will allow parallel moves to and from the Stoughton Branch. The present plan is to signal the parallel moves for 30 mph, due to civil restrictions on the Stoughton Branch.

Additionally, MBTA main line trains will no longer stop at Canton Junction Station during peak periods. This station will be served by trains from the Stoughton Branch .

4.5 ATTLEBORO BYPASS

The Attleboro Bypass has already been discussed in some detail. Its precise location has not been finalized. However, it is clear from field observations and from preliminary design documents that it will be located in the vicinity of the Gilbert Street overpass west of the Elm Street overpass, close to Milepost 200. The approximate location of this junction seems to be at an existing power line right-of-way that intersects the Northeast Corridor.

To provide for parallel moves, the proposed design incorporates a single #32 crossover from Track 1 to Track 2 in the westbound direction and two #32 turnouts located on Track 2

The simulation provides for an 80 mph civil diverging move and signaling to support this speed. No signal control line design documents existed at the time the simulation was developed. Therefore, assumptions were made consistent with typical North American signaling practices.

4.6 CIVIL SPEED RESTRICTIONS, EXISTING NEC

Many civil speed restrictions between New Haven and Boston are scheduled to be upgraded as part of the Northeast High-speed Rail Improvement Project. This involves track realignments to superelevation changes. All Amtrak trains, both "conventional" and "high-speed", will be affected by these changes. MBTA trains will be indirectly affected in that headways between Amtrak and MBTA trains have to be adjusted to avoid the possibility of the faster Amtrak trains overtaking MBTA trains and incurring signal delay.

The simulation models incorporated an extensive list of civil speed restriction changes. Two separate sets of speed restrictions were supplied by Amtrak: one applying to "high-speed" trains and one applying to "conventional" (i.e., Metroliner-type) trains.

4.7 NINE-ASPECT CAB SIGNAL SYSTEM, EXISTING NEC

The present cab signal system on the NEC is being replaced with a signal system capable of supporting 150 mph train operations. The important operating change to the MBTA will be an additional code rate that will enable trains to utilize the high speed turnouts that are planned for Hebronville and the Attleboro Bypass junction. The new cab signal system has important implications for capacity and throughput. Notably, the longer control lines necessary to provide safe braking distance for high-speed trains will generally increase signal clearing times for following trains. The new system will also require greater headways between the high-speed trains and any other rail traffic in order to avoid cab signal speed reductions.

It is important to note that current MBTA trains will not be capable of interpreting all of the proposed nine-aspect cab rates of the new signal system. It will be necessary for the MBTA to retrofit their locomotives to receive these new rates and take advantage of the higher speed diverging moves. Not all code rates (for all nine aspects, Stop-15 mph-30 mph-45 mph-60 mph-80 mph-100 mph-120 mph-150 mph) will be active in all blocks, at all locations. This is because of complex design issues involving diverging routes, signaling of civil speed restrictions and safe braking distance criteria which must take into account speed and vertical profile (grades).

The final signal design for NEC was not complete at the time of this study. Therefore, it was necessary to make assumptions and estimates based on generally-accepted signaling practice.

5.0 ASSUMPTIONS, YEAR 2010

5.1 AMTRAK AND MBTA SERVICE AND EQUIPMENT

Amtrak service will increase from 34 trains per day in Year 2000 to 52 trains per day in Year 2010. This does not include the possibility of additional off-peak mail and express trains, and does not include Amtrak service on the Boston & Albany Line via Springfield, Massachusetts. Timings for this incremental service expansion have already been identified by Amtrak and were utilized accordingly to develop the Year 2010 simulations. The simulation assumes continued operation of one mail and express train on the Corridor -- currently #12 and #13.

MBTA's peak-period service goals for Year 2010 as they pertain to the MBTA's Providence Line and its connecting branches are the following:

- Needham Line - 2 trains per hour
- Franklin Line - 4 trains per hour
- Stoughton Line - 2 trains per hour
- Providence Line - 2 trains per hour

These targets were attained in the peak direction. However, this is not necessarily true in the reverse-peak direction due to capacity constraints. Equipment manipulation and crew assignment was beyond this scope.

5.2 TRACK AND SIGNAL IMPROVEMENTS AT HOLDEN INTERLOCKING

Holden Interlocking controls the east end of Track 4 at Attleboro, located just east of Milepost 198. It also controls access to certain industrial tracks. The east end turnout of Track 4 is to be upgraded to a #32 turnout, supporting an 80 mph merging move. Thatcher and Boro Interlockings, located on each side of Attleboro Station, would be removed.

The upgraded turnout and supporting signal control lines were modeled without changing the limits of Holden Interlocking. All eastbound MBTA trains serving Attleboro were routed to Track 4 from Hebronville to Holden interlockings.

5.3 TRACK 3 EXTENSION, "TRANSFER INTERLOCKING " TO ROUTE 128 STATION

Early in the development of the Year 2010 simulation, it became clear that the proposed extension of Track 3 westward from Transfer Interlocking to a point west of the present Route 128 Station would be necessary. This project is scheduled to be in service by Year 2010. Signal system design for the extension and for the new interlocking that will be necessary to support this proposed extension does not exist. It was developed assuming generally-accepted practices. It is likely that refinements made during preliminary design, including safe braking distance computations, will result in control lines and signal aspects that differ somewhat from the present simulation database.

The traffic pattern and a fair representation of the degree of capacity enhancement to be expected from this project was achieved, however. A #32 turnout was emulated at the west end of the extended Track 3 with an 80 mph diverging/merging speed. Because the assumed location of this new turnout is approximately one mile west of the present location of Route 128 Station, and the intervening vertical profile is level to slightly ascending, it should be practical for westbound trains to accelerate close to this speed prior to reaching the turnout in the westbound direction. In the eastbound direction on the extension of Track 3, 6,272 feet of level tangent is required to meet Amtrak's CE-205 safe braking criteria from 80 mph to zero so that an eastbound train can stop safely and reliably at the Route 128 station.

5.4 TRACK AND SIGNAL IMPROVEMENTS AT READVILLE

The diverging speed to the Franklin Branch at Read Interlocking was upgraded from the present 30 mph to 45 mph, consistent with MBTA plans. This improvement primarily benefits westbound traffic.

5.5 PROVIDENCE LAYOVER FACILITY

The MBTA has indicated that it anticipates a new layover facility in Providence to replace or augment the present facility at "East Junction" (between South Attleboro and Attleboro). This would eliminate deadhead moves between East Junction and Providence. This freed up valuable track capacity for revenue traffic.

There are numerous issues concerning a new layover facility at Providence that are outside the scope of this report. It was assumed that this facility would be sited and constructed by Year 2010.

5.6 RUGGLES STATION PLATFORM CONSTRUCTION

A platform adjacent to Track 2 at Ruggles will be in service by Year 2010, consistent with MBTA's present planning. This will enable eastbound MBTA trains to make station stops at Ruggles on Track 2, while freeing up capacity on Track 3 for other MBTA trains.

6.0 RESULTS OF YEAR 2000 SIMULATIONS

For Year 2000, thirty-four New Bedford/Fall River (NB/FR) trains were successfully implemented between 5:30 AM and 8:00 PM each weekday. Prior to 5:30 AM and after 8:00 PM capacity historically exceeds demand and scheduling of additional, 60 minute services is not an issue. A full complement of MBTA services on the existing Needham, Franklin, Stoughton and Providence routes was included, as well as Amtrak's target services for Year 2000.

At the level of NB/FR service indicated, cumulative signal delay minutes between 4:00 p.m. and 8:00 p.m. increased from 52 minutes 35 seconds without the NB/FR trains to 101 minutes 9 seconds with the NB/FR trains. Again, signal delays do not equate evenly to train delays, as previously discussed in this report.

Due to 30 mph speed restrictions eastbound into Back Bay Station, imposed in the late 1980's, the Year 2000 simulation model found that numerous delays occur during the morning peak period.

6.1 NEW BEDFORD/FALL RIVER SERVICE DEVELOPMENT

Current Amtrak services were considered to be a constraint with little or no flexibility. This required adjusting MBTA schedules from one to ten minutes, and altering stopping patterns, mostly involving Ruggles Station where there is no platform access off of Track 2. When New Bedford/Fall River services are inaugurated, lack of platform access at Ruggles Station will become an immediate constraint. Stopping patterns had to be adjusted, which reduced even the present level of service to this station by Providence and Stoughton trains.

A stable operating plan was established and string charts were generated in order to identify time slots available for additional traffic. A string chart is a graph of train operations with stations and interlockings laid out in sequence on the Y-axis and time on the X-axis. Train operations are depicted as diagonal lines; fast trains are indicated by a steep line, while stopped trains produce a straight vertical line. Intersecting lines reveal meets and overtakes.

The addition of NB/FR service required significant alterations to the stopping pattern of many existing MBTA Providence/Attleboro services. NB/FR trains will be scheduled to stop at Sharon and Back Bay, eastbound, during the morning peak; NB/FR trains will be scheduled to stop at Back Bay, Ruggles and Sharon westbound during the evening peak. These schedule changes will allow some Providence trains to skip Sharon Station, with minimal impact on service.

Exhibit 1 displays the Year 2000 frequency of service and anticipated schedule for NB/FR service. This table displays a frequency of service of 22 to 43 minute peak service and 60 minutes off-peak service. Minor schedule readjustments were made to achieve the maximum possible NB/FR service. Estimated running time between the Attleboro Bypass junction and South Station based on simulations is approximately 43 to 50 minutes, depending on the number of station stops. For the purpose of this study, all NB/FR trains were assumed to stop at Back Bay Station. The shorter trip time was achieved by an express train making the minimum number of stops necessary. Run times from the Attleboro junction to Fall River and New Bedford are not included in this plan.

Two capacity constraints, other than South Station include:

- Track 1, westbound, between Route 128 and Canton Junction during peak periods.
- Tracks 2 and 3, eastbound, between Ruggles and Back Bay during the AM Peak.

The 30 mph diverging move at Canton Junction tends to cause ripple-effect delays to following traffic between Route 128 and Canton Junction during peak periods. Although the reconstruction of Canton Junction will improve operations, operation of an MBTA Stoughton train ahead of an MBTA Providence or NB/FR train, or an Amtrak train (either conventional or high-speed) is undesirable. This limits suitable "slots" for Stoughton trains to those that are not closely bounded by following through traffic.

Exhibit 1

NEW BEDFORD/FALL RIVER OPERATING PLAN
YEAR 2000

EASTWARD

TRAIN	ARRIVE SOUTH STATION	STOPS	FREQUENCY OF SERVICE
NB/FR00	5:56 AM	MFD,SHN,RTE,HYD,BAC	--
NB/FR02	6:55 AM	MFD,SHN,RTE,HYD,BAC	0:59
NB/FR04	7:23 AM	SHN,BAC	0:28
NB/FR06	7::53 AM	SHN,BAC	0:30
NB/FR08	8:23 AM	SHN,BAC	0:30
NB/FR10	8:43 AM	SHN,BAC	0:20
NB/FR12	9:34 AM	MFD,SHN,RTE,HYD,BAC	0:51
NB/FR14	10:36 AM	MFD,SHN,RTE,HYD,BAC	1:02
NB/FR16	11:36 AM	MFD,SHN,RTE,HYD,BAC	1:00
NB/FR18	12:28 AM	SHN,BAC	0:52
NB/FR20	1:28 PM	MFD,SHN,RTE,HYD,BAC	0:52
NB/FR22	2:28 PM	MFD,SHN,RTE,HYD,BAC	1:00
NB/FR24	3:26 PM	MFD,SHN,RTE,HYD,BAC	0:58
NB/FR26	4:31 PM	MFD,SHN,RTE,HYD,BAC	1:05
NB/FR28	5:38 PM	SHN,BAC	1:07
NB/FR30	6:46 PM	MFD,SHN,RTE,HYD,BAC	1:08
NB/FR32	8:11 PM	MFD,SHN,RTE,HYD,BAC	1:25

BAC = BACK BAY
HYD = HYDE PARK
SHN = SHARON

RUG = RUGGLES
RTE = ROUTE 128
MFD = MANSFIELD

Exhibit 1, continued

NEW BEDFORD/FALL RIVER OPERATING PLAN
YEAR 2000

WESTWARD

TRAIN	DEPART SO. STA.	STOPS	FREQUENCY OF SERVICE
NB/FR01	5:45 AM	BAC,RUG,HYD,RTE,SHN,MFD	--
NB/FR03	6:50 AM	BAC,RUG,RTE,SHN,MFD	1:05
NB/FR05	7:55 AM	BAC,RUG,RTE,SHN,MFD	1:05
NB/FR07	8:50 AM	BAC,RUG,RTE,SHN,MFD	0:55
NB/FR09	10:00 AM	BAC,RUG,SHN	1:10
NB/FR11	10:55 AM	BAC,RUG,HYD,RTE,SHN,MFD	0:55
NB/FR13	11:59 AM	BAC,RUG,SHN	1:04
NB/FR15	12:50 PM	BAC,RUG,HYD,RTE,SHN,MFD	0:51
NB/FR17	1:55 PM	BAC,RUG,SHN	1:05
NB/FR19	3:00 PM	BAC,RUG,SHN	1:05
NB/FR21	4:00 PM	BAC,RUG,SHN	1:00
NB/FR23	4:40 PM	BAC,RUG,SHN	0:40
NB/FR25	5:05 PM	BAC,RUG,SHN	0:25
NB/FR27	5:40 PM	BAC,RUG,SHN	0:35
NB/FR29	6:05 PM	BAC,RUG,HYD,RTE,SHN,MFD	0:25
NB/FR31	6:30 PM	BAC,RUG,HYD,RTE,SHN,MFD	0:25
NB/FR33	7:00 PM	BAC,RUG,HYD,RTE,SHN,MFD	0:30

BAC = BACK BAY
HYD = HYDE PARK
SHN = SHARON

RUG = RUGGLES
RTE = ROUTE 128
MFD = MANSFIELD

6.2 ON-TIME PERFORMANCE, IDEAL SIMULATION, MORNING PEAK

The following table displays on-time performance eastbound at Route 128 Station during the morning peak period for the ideal simulation.

On-Time Performance at Route 128 Station, Ideal Operations
Peak Direction (Eastbound), 6-10 A.M.
Year 2000 Operations

Agency	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
MBTA	9	2	5	0	0	0	16
Amtrak	1	0	0	1	0	0	2

The following tables display on-time performance for the same simulation model, with New Bedford/Fall River trains removed from simulation. No changes were made to the timetable.

On-Time Performance at Route 128 Station, Ideal Operations,
Without New Bedford/Fall River Trains
Peak Direction (Eastbound), 6-10 A.M.
Year 2000 Operations

Agency	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
MBTA	6	0	4	0	0	0	10
Amtrak	1	0	0	1	0	0	2

The preceding tables show that the addition of six NB/FR trains did not adversely affect NEC planned operations. Seven eastbound MBTA trains did experience minor delays at Route 128 Station. In an effort to quantify NB/FR trains affect on the NEC, a simulation was run omitting them from service. The results showed that three of these delays were directly attributed to NB/FR service. In the westbound direction, at Canton Junction, there were no adverse affects prior to or after NB/FR trains were implemented on the NEC.

6.3 ON-TIME PERFORMANCE, DELAY SIMULATED, MORNING PEAK

The final set of on-time performance tables for morning peak operations in the Year 2000 displays the results of delay simulated operations with the complete NEC operations. For this simulation, delay simulated delays were utilized at the Attleboro Bypass and Providence. This emulated random delays that might occur between Fall River or New Bedford and the Attleboro Bypass, or, on the Northeast Corridor, west of Providence.

For delay simulation, MBTA trains were permitted to range up to two minutes early and up to five minutes late, with an offset of 75 seconds (i.e., the curve is skewed by 75 seconds of lateness) and a standard deviation of 150 seconds. For Amtrak trains, the range was -120 seconds to +600 seconds (10 minutes late), with same offset and standard deviation. The statistical parameters used for delay simulation were from ten seconds less to sixty seconds more dwell time at any given station. These profiles are not arbitrary, but have been developed through experience on other properties in an attempt to reflect reality. For example, a commuter train that is five minutes late would be considered significantly late on most properties; but an Amtrak train traveling from Washington to Boston that is ten minutes late at Providence has historically not been regarded as significantly behind schedule.

Station dwells vary from one day to another due to unusual passenger travel, an accommodating conductor waiting for a tardy passenger, the presence of passengers who require a bit of extra time to board or exit the train, and weather conditions.

The following table indicates on-time performance eastbound at Route 128 Station for the delay simulated Year 2000 simulation.

On-Time Performance at Route 128 Station, Delay Simulated Operations
Peak Direction (Eastbound), 6-10 A.M.
Year 2000 Operations

Agency	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
MBTA	4	3	6	3	0	0	16
Amtrak	1	0	0	1	1	0	2

An increase in the number of late trains is typical. Eastbound at Route 128, the number of late MBTA trains has increased from 7 to 12, consisting of one additional train one to ten seconds late, one additional train ten seconds to one minute late, and three trains one to three minutes late. Trains that are ten seconds late are "on time", so an increase in this category is not cause for concern. The delay simulated offset is 300 seconds (5 minutes), yet the maximum lateness eastbound at Route 128 is not more than three minutes, indicating that even with NB/FR services operating, there is some ability to recover from delays. The system is less stable, but not to the point where operations become seriously disrupted.

6.4 ON-TIME PERFORMANCE, IDEAL SIMULATION, EVENING PEAK

The following data table displays westbound (peak direction) on-time performance for the ideal Year 2000 simulation during the evening peak period. On-time performance at Canton is measured at the new Canton Junction Station, located on the Stoughton Branch. On-time performance at the Attleboro Bypass is measured as the train enters the Bypass.

On-Time Performance at Canton and Providence Stations, and
Attleboro Bypass, Ideal Operations
Peak Direction (Westbound), 4-8 P.M.
Year 2000 Operations

	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
Canton Station							
MBTA	0	0	1	3	1	0	5
Attleboro Bypass							
MBTA	5	1	0	0	0	0	6
Providence Station							
MBTA	3	0	1	2	1	0	7
Amtrak	4	0	0	0	0	0	4

The following data table displays westbound (peak direction) on-time performance for the ideal Year 2000 simulation during the evening peak period, without New Bedford/Fall River trains. On-time performance at Canton is measured at the new Canton Junction Station, located on the Stoughton Branch. On-time performance at the Providence Station is measured at that location.

On-Time Performance at Canton and Providence stations, and
Attleboro Bypass, Ideal Operations,
Without New Bedford/Fall River Trains
Peak Direction (Westbound), 4-8 P.M.
Year 2000 Operations

	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
Canton Station							
MBTA	0	0	1	3	1	0	5
Attleboro Bypass							
MBTA	0	0	0	0	0	0	0
Providence Station							
MBTA	3	0	1	3	0	0	7
Amtrak	4	0	0	0	0	0	4

The above tables show that the additional six NB/FR trains did not adversely affect NEC planned operations. At Providence, one MBTA train in the one-to-three minutes late category without NB/FR train services, performed in the three-to-five minutes lateness category when NB/FR trains were operating. Stoughton Branch service still suffered from scheduling difficulties, but the problem was not caused by NB/FR trains. Additional schedule time will probably be needed for peak period westbound Stoughton Branch traffic to reach Canton on schedule.

6.5 ON-TIME PERFORMANCE, DELAY SIMULATED, EVENING PEAK

The final set of on-time performance tables for evening peak operations in the Year 2000 display the results of delay simulated operations with the full complement of Year 2000 NB/FR services, plus planned Amtrak services and MBTA services on existing routes. Delay simulation is an attempt to mimic real-world variations in station dwells and delays. For this simulation, the only locations at which delays were utilized were the Attleboro Bypass and at Providence. This emulated random delays that might occur between Fall River or New Bedford and the Attleboro Bypass, or, on the Northeast Corridor, west of Providence.

The following data table displays westbound (peak direction) on-time performance for the delay simulated Year 2000 simulation during the evening peak period. On-time performance at Canton is measured at the new Canton Junction Station, located on the Stoughton Branch. On-time performance at the Attleboro Bypass is measured as the train enters the Bypass.

On-Time Performance at Canton and Providence Stations, and
Attleboro Bypass, Delay Simulated Operations
Peak Direction (Westbound), 4-8 P.M.
Year 2000 Operations

	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
Canton Station							
MBTA	0	0	0	1	2	2	5
Attleboro Bypass							
MBTA	1	1	3	1	0	0	6
Providence Station							
MBTA	3	0	0	1	2	1	7
Amtrak	4	0	0	0	0	0	4

An increase in the number of late trains is typical. On-time performance of Stoughton Branch trains has degraded somewhat, with all five of five trains at least one minute late; but all Stoughton Branch trains were already at least slightly late even in the ideal simulation. On-time performance of New Bedford/Fall River trains suffers considerably. In the ideal simulation, on-time performance was nearly 100% (one train was not more than ten seconds "late" arriving at the Bypass from South Station); in the delay simulation, five out of six NB/FR trains are up to three minutes late in the peak direction between 4:00 PM and 8:00 PM. At Providence, Amtrak maintained perfect westbound on-time performance and MBTA performance deteriorated only slightly.

The degraded on-time performance during the peak period is not surprising. The operation was made less stable by random delays that are typical of actual conditions. However, the extent of on-time degradation was consistent with the delay simulation profiles. This suggests that, while the system has difficulty recovering from induced delays during the evening peak period, these delays do not show a tendency to amplify. The ability of the system to recover from these random delays could be characterized as "neutral".

6.6 SIGNAL DELAY STATISTICS

Signal delay is a very good measure of the extent of conflicts caused by opposing and following trains operating on rail system. Signal delay minutes were calculated automatically by RAILSIM®. Delays incurred by non-revenue trains, while operating on branch lines, were not included in the totals.

As previously explained, a signal delay is accrued when a train is slowed or stopped by a signal indication. Below are the results for the Year 2000 simulation during the period from 4:00 to 8:00 PM.

The methodology involved running the ideal simulation with and without the NB/FR trains. Results produced total signal delay and the percent changed for each simulation.

Simulation	Total Signal Delay	Percent change
Year 2000,NB/FR suspended,	52 minutes 35 seconds	(datum)
Year 2000, all trains	101 minutes 9 seconds	92.4%
Year 2000,delay simulated, all trains	133 minutes 25 seconds	153.7%

New Bedford/Fall River service introduces a higher level of congestion. The operation held up reasonably well under delay simulation.

6.7 OPERATIONS IMPACT OF DIESEL MULTIPLE-UNIT EQUIPMENT

The Swedish-Swiss conglomerate, ABB, is marketing a new generation of DMU (diesel multiple-unit) vehicles in Europe known as the IC-3. The Appendix includes a detailed description of Vehicles and Vehicle Performance. Preliminary data indicate that the IC-3 has acceleration and braking characteristics that are superior to those of typical push-pull consists. Use of DMU vehicles is one means the MBTA may have of achieving minimum service headways on the Fall River and New Bedford branches without requiring a cross-platform change. This would be accomplished by joining/separating DMU sets at or near Taunton Station. Because passengers would be occupying the vehicles during this procedure, it could be subject to scrutiny for safety reasons.

This analysis of the IC-3 focused strictly on its ability to maintain schedule without exacerbating signal delays on the NEC. This was done by substituting the acceleration/braking performance of the IC-3 in place of diesel-powered (in Year 2000) or electric-powered (in Year 2010) push-pull NB/FR trains, while leaving the timetable intact.

Two Year 2000 simulations were run with the IC-3 DMU equipment assigned to NB/FR trains. The first simulation limited the IC-3 to an 80 mph top speed, consistent with present and projected Year 2000 MBTA service; in the second simulation, the IC-3 performed at 100 mph, or the maximum civil speed, wherever conditions permitted.

In both simulations, the superior acceleration and braking performance of the IC-3 allowed the NB/FR trains to "close in" behind the trains immediately preceding them. This, together with a higher top speed in the second simulation, freed up signal blocks more quickly for following moves, which greatly reduced the delay to following trains. Critical junctions were also cleared more quickly, where civil speeds permitted.

These results can be seen in the accompanying table, during the peak period of 4:00 PM to 8:00 PM. In addition to freeing up signal blocks behind them, the IC-3s also tended to close in on trains immediately preceding them during peak periods. The faster IC-3 NB/FR trains (100 mph) experienced greater signal delays themselves as they closed in behind trains ahead. While total signal delay experienced by all trains was less in both of the IC-3 Year 2000 simulations than it was in the original Year 2000 simulation, the additional delay experienced by the faster (100 mph) IC-3 trains was barely offset by a corresponding drop in delay to other trains.

Comparative Signal Delay Results with ABB IC-3 DMU
Revenue Trains, Both Directions, 4-8 PM
Year 2000 Operations

Delay to Simulation	Delay experienced by FR/NB trains	Delay experienced by all other trains	Total Signal Delay
Year 2000 Final	29' 22"	71'47"	101' 09"
Year 2000 IC-3 DMU, 80 mph	40' 36"	41'24"	82' 00"
Year 2000 IC-3 DMU, 100 mph	55' 31"	40'09"	95' 40"

At an imposed 80 mph cap on maximum speed, the IC-3s reduce the signal delay to following trains moreover than to themselves because of closing in on trains ahead. This does not, however, yield a net improvement in operations. When delays did occur, the IC-3 was better able to recover schedule time than diesel-hauled push-pull trains, with a maximum speed of 75-80 mph.

The simulation schedule was developed for conventional locomotive-hauled NB/FR trains to minimize total signal delay and maximize overall on-time performance. A schedule developed with the IC-3 in mind, especially one contemplating 100 mph maximum speed, would take advantage of the performance characteristics of the IC-3. Following Amtrak trains could be scheduled closer behind an IC-3 without delays. Unfortunately, given other Year 2000 constraints, pushing back an IC-3 departure time could not be done when a closely following train is a conventional (diesel) MBTA train, since the MBTA train would have to depart later as well (to maintain terminal headway behind the IC-3), resulting in lost capacity.

In conclusion, if a North American version of an IC-3 matched the performance of the European model, the vehicle would be compatible with Year 2000 operations on the Northeast Corridor, operating at a top speed of approximately 80 mph. With timetable modifications, the IC-3 could be permitted to operate at a higher maximum speed and this appears to be well within the capability of the vehicle.

7.0 RESULTS OF YEAR 2010 SIMULATIONS

For the Year 2010 simulation, 38 New Bedford/Fall River (NB/FR) trains were successfully implemented between 6:00 AM and 8:00 PM each weekday. The simulation included the full complement of MBTA services and planned improvements on the existing Needham, Franklin, Stoughton and Providence routes, as well as Amtrak's target services for Year 2010.

At the level of NB/FR service indicated, cumulative signal delay minutes between 4:00 p.m. and 8:00 p.m. more than doubled from 41 minutes 42 seconds without the NB/FR trains to 101 minutes 28 seconds with the NB/FR trains. Again, signal delays do not equate evenly to train delays, as previously discussed. South Station capacity becomes acute by Year 2010, which contributed to scheduling difficulties.

In the Year 2010, it is undetermined whether MBTA locomotives will be straight-electric or diesel-electric/electric dual-mode. For the purposes of this study, it was assumed that catenary will be extended onto the Attleboro Bypass from the Northeast Corridor. This would be a distance sufficient to make transfers from electric to diesel on the Bypass, rather than the NEC. This situation would maximize the performance of NB/FR trains on the NEC, as well as preclude the possibility of a train becoming disabled on the NEC in the event that normal power transitioning should fail.

7.1 NEW BEDFORD/FALL RIVER SERVICE DEVELOPMENT

As with the Year 2000 model, in Year 2010, MBTA and Amtrak services were considered to be constraints with little or no flexibility. However, three Amtrak schedules were changed to facilitate the operation of convenient MBTA peak period, peak direction schedules. The first change was that the Inbound #66, "the Night Owl", remained at the Year 2000 schedule of a 7:15 AM arrival time. The Year 2010 scheduled 8:00 AM arrival time could not be supported under the Year 2010 simulation and was, therefore, maintained at 7:15 AM.

The last two changes made to the Amtrak schedule involved changing the high-speed, westbound, peak period trains (the 4:40 PM and 5:40 PM) back ten minutes to half past the hour. Schedules of MBTA commuter trains in the PM peak would not be departing at times convenient to the close of the workday.

Year 2000 MBTA services plus implementation of MBTA's target service goals for Year 2010 were developed and adjusted to operate without interfering with Amtrak operations. Certain capacity enhancements and facilities improvements, such as the extension of Track 3 to one mile west of Route 128 Station and the planned construction of a platform serving Track 2 at Ruggles Station, eased service planning somewhat. With a stable operating plan without NB/FR trains, string line diagrams, as displayed in Appendix A, were generated to identify time slots available for additional traffic.

The addition of NB/FR service required some further refinements to stopping patterns of Year 2000 MBTA services. The simulation model indicated that during peak periods, capacity would be inadequate to operate existing MBTA or NB/FR trains that would make all existing station stops. This lead to the development of a schedule of all-day "zone" express service for the MBTA on the NEC. It would also be difficult to schedule reverse-peak MBTA service. Even though MBTA trains will be operating at a higher speed in Year 2010 (100 mph, up from 80 mph), there will be more rail traffic on the NEC. The proposed service plan contemplates stops at Sharon, Ruggles and Back Bay for all NB/FR trains, with Mansfield substituted for Sharon during the P.M. peak.

In keeping with MBTA Year 2010 proposed plan, zone express service on the Franklin Line was provided by extension and combination with the Dorchester Line. One additional inbound AM peak train was added to the Franklin line that was routed via the NEC. All peak period inner-zone Franklin service was provided by extended Dorchester trains. All reverse-peak Franklin service was operated via Dorchester. Existing midday and evening Franklin service remained on the NEC. Additional off-peak service was provided via the Dorchester Line.

Exhibit 2 displays the Year 2010 frequency of service and anticipated schedule for NB/FR service. This table displays a frequency of service of 21 to 38 minute peak service and 60 minutes off-peak service.

Estimated running time between the Attleboro Bypass junction and South Station based on simulations is approximately 43 minutes, with three intermediate station stops. For the purpose of this study, all NB/FR trains were assumed to stop at Back Bay Station. Run times from the Attleboro junction to Fall River and New Bedford are not included in this plan.

Capacity constraints, other than South Station, included:

- Track 1 west of Track 3 extension, west of Route 128 Station during the P.M. peak
- Tracks 2 and 3, eastbound, between Ruggles and Back Bay during the AM peak
- Canton Junction and the Attleboro Bypass/NEC junction during both peak periods

Simulations indicate that, during the PM peak, congestion will occur west of the Route 128 Station on Track 1. This is the result of trains diverging onto the Stoughton Line.

Tracks 2 and 3 are capacity-constrained eastbound between Ruggles Station and Back Bay during the AM peak. The new cab signal system in its preliminary design requires a 30 mph top speed between Ruggles and Back Bay. This causes numerous ripple-effect delays during the morning peak period.

The 30 mph diverging move at Canton Junction tends to cause ripple-effect delays to following traffic between Route 128 and Canton Junction during peak periods. This was discussed in connection with the Year 2000 simulations. The problem of Canton Junction is exacerbated in Year 2010 because of increased traffic. A similar problem begins to occur at the Attleboro Bypass/NEC interface by Year 2010 caused by opposing (opposite-direction) NEC traffic. Careful planning is necessary to avoid delays to westbound NB/FR trains caused by eastbound NEC trains.

Amtrak's request that a passing siding be constructed at Sharon was not supported by simulation results. Concerns regarding capacity constraints between Canton Junction and Back Bay were confirmed. Planned improvements to Track 3 and Ruggles Station partially address these concerns.

Exhibit 2

NEW BEDFORD/FALL RIVER OPERATING PLAN
YEAR 2010

EASTWARD

TRAIN	ARRIVE SOUTH STATION	STOPS	FREQUENCY OF SERVICE
NB/FR00	6:55 AM	SHN,RUG,BAC	–
NB/FR02	7:20 AM	SHN,RUG,BAC	0:25
NB/FR04	7:45 AM	SHN,RUG,BAC	0:25
NB/FR06	8:09 AM	SHN,RUG,BAC	0:24
NB/FR08	8:38 AM	SHN,RUG,BAC	0:29
NB/FR10	9:30 AM	SHN,RUG,BAC	0:52
NB/FR12	10:35 AM	SHN,RUG,BAC	0:55
NB/FR14	11:25 AM	SHN,RUG,BAC	1:00
NB/FR16	12:25 AM	SHN,RUG,BAC	1:00
NB/FR18	1:25 PM	SHN,RUG,BAC	1:00
NB/FR20	2:25 PM	SHN,RUG,BAC	1:00
NB/FR22	3:25 PM	SHN,RUG,BAC	1:00
NB/FR24	4:25 PM	SHN,RUG,BAC	1:00
NB/FR26	5:25 PM	SHN,RUG,BAC	0:58
NB/FR28	6:50 PM	SHN,RUG,BAC	1:26
NB/FR30	7:50 PM	SHN,RUG,BAC	0:58

BAC = BACK BAY
RUG = RUGGLES
SHN = SHARON

Exhibit 2, Continued

NEW BEDFORD/FALL RIVER OPERATING PLAN
YEAR 2010

WESTWARD

TRAIN	DEPART SO. STA.	STOPS	FREQUENCY OF SERVICE
NB/FR01	7:00 AM	BAC,RUG,SHN	--
NB/FR03	8:20 AM	BAC,RUG,SHN	1:20
NB/FR05	9:20 AM	BAC,RUG,SHN	1:00
NB/FR07	10:20 AM	BAC,RUG,SHN	1:00
NB/FR09	11:20 AM	BAC,RUG,SHN	1:00
NB/FR11	12:20 PM	BAC,RUG,SHN	1:00
NB/FR13	1:20 PM	BAC,RUG,SHN	1:00
NB/FR15	2:20 PM	BAC,RUG,SHN	1:00
NB/FR17	3:20 PM	BAC,RUG,SHN	1:00
NB/FR19	4:15 PM	BAC,RUG,SHN	0:55
NB/FR21	4:35 PM	BAC,RUG,MFD	0:20
NB/FR23	5:00 PM	BAC,RUG,MFD	0:25
NB/FR25	5:30 PM	BAC,RUG,MFD	0:30
NB/FR27	5:55 PM	BAC,RUG,MFD	0:25
NB/FR29	6:20 PM	BAC,RUG,MFD	0:25
NB/FR31	6:45PM	BAC,RUG,MFD	0:25
NB/FR31	7:15 PM	BAC,RUG,SHN,	0:30

BAC = BACK BAY
RUG = RUGGLES
SHN = SHARON
MFD= MANSFIELD

7.2 ON-TIME PERFORMANCE, IDEAL SIMULATION, MORNING PEAK

The following table displays on-time performance eastbound at Route 128 Station during the morning peak period for the ideal simulation. In all of the data tables that follow, the number appearing in the "Total" category is the total number of revenue trains operated to or via the referenced station during the stated time period, not the number of late trains. The time categories represent lateness relative to schedule.

On-Time Performance at Route 128 Station, Ideal Operations
Peak Direction (Eastbound), 6-10 AM
Year 2010 Operations

Agency	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
MBTA	1	7	7	4	2	0	21
Amtrak	2	0	0	2	0	0	4

It was observed that westbound Amtrak "conventional" trains spent time at Route 128 waiting for schedule (dwelling up to five minutes), then tended to arrive late at Providence or barely on time. A slight schedule adjustment would solve this problem; Amtrak's station to station running times were utilized as furnished by Amtrak and were not altered.

The following tables display on-time performance for the same simulation model, with New Bedford/Fall River trains removed from simulation. No changes were made to the timetable.

On-Time Performance at Route 128 Station, Ideal Operations,
Without New Bedford/Fall River Trains
Peak Direction (Eastbound), 6-10 AM
Year 2010 Operations

Agency	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
MBTA	1	1	7	4	2	0	15
Amtrak	2	0	0	2	0	0	4

It is clear by comparing the two sets of on-time results that the presence of six NB/FR trains during the morning peak period did not adversely affect the on-time performance of "existing" traffic. Twenty MBTA trains were late at Route 128, eastbound, when all NB/FR services were running, including 14 trains not more than one minute "late". This total dropped by six when NB/FR services were suspended.

7.3 ON-TIME PERFORMANCE, DELAY SIMULATED, MORNING PEAK

The final set of on-time performance tables for morning peak operations in the Year 2010 display the results of delay simulated operations with the full complement of Year 2010 NB/FR services, plus planned Amtrak services and MBTA services on existing routes. Delay Simulation is an attempt to mimic real-world variations in station dwells and delays. For this simulation, the only locations at which delays were utilized were the Attleboro Bypass and at Providence. This emulated random delays that might occur between Fall River or New Bedford and the Attleboro Bypass, or, on the Northeast Corridor, west of Providence.

The following table displays lateness statistics eastbound at Route 128. This is the peak direction during the morning peak period.

On-Time Performance at Route 128 Station, Delay Simulated Operations
Peak Direction (Eastbound), 6-10 AM
Year 2010 Operations

Agency	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
MBTA	0	3	0	10	4	4	21
Amtrak	0	0	1	0	3	0	4

The number of late trains has not increased significantly, but the degree of lateness has. There has been a large shift in eastbound MBTA performance from 20 late trains of which 18 were not more than three minutes late at Route 128 to 21 late trains of which ten were 1:01 to 3:00 late, four were 3:01 to 5:00 late and another four were more than five minutes late, which is unacceptable. The latest eastbound MBTA train was 7:45 late; this is unacceptable for a commuter rail operation. The eastbound Year 2010 morning operation is choking on more trains than the signal system can accommodate and induced random delays of up to five minutes from Providence (plus modest, random dwell delays) are beginning to amplify. At a minimum, additional schedule "pad" would be called for in the eastbound direction during the morning peak period. However, this simply masks the underlying problem of inadequate capacity.

7.4 ON-TIME PERFORMANCE, IDEAL SIMULATION, EVENING PEAK

The following data table displays westbound (peak direction) on-time performance for the ideal Year 2010 simulation during the evening peak period. On-time performance at Canton is measured at the new Canton Junction Station, located on the Stoughton Branch. On-time performance at the Attleboro Bypass is measured as the train enters the Bypass.

On-Time Performance at Canton and Providence stations, and Attleboro Bypass, Ideal Operations
Peak Direction (Westbound), 4-8 PM
Year 2010 Operations

	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
Canton Station							
MBTA	0	0	0	5	1	0	6
Attleboro Bypass							
MBTA	5	1	1	0	0	0	7
Providence Station							
MBTA	5	0	0	2	0	0	7
Amtrak	6	0	0	0	0	0	6

The following data table displays westbound (peak direction) on-time performance for the ideal Year 2010 simulation during the evening peak period, without New Bedford/Fall River trains. On-time performance at Canton is measured at the new Canton Junction Station, located on the Stoughton Branch. On-time performance at the Attleboro Bypass is measured as the train enters the Bypass.

On-Time Performance at Canton and Providence Stations, and
Attleboro Bypass, Ideal Operations,
Without New Bedford/Fall River Trains
Peak Direction (Westbound), 4-8 PM
Year 2010 Operations

	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
Canton Station							
MBTA	0	0	1	4	1	0	6
Attleboro Bypass							
MBTA	0	0	0	0	0	0	0
Providence Station							
MBTA	5	0	1	1	0	0	7
Amtrak	6	0	0	0	0	0	6

It is clear by comparing the two sets of evening peak on-time results that the presence of seven NB/FR trains during the evening peak period did not adversely affect the on-time performance of "existing" traffic. The Stoughton Branch still suffers from inadequate running time from Boston, and this is not due to NB/FR traffic. One train improved from the 1:01 to 3:00 lateness category to the 0:10 to 1:00 lateness category. Five other Stoughton Branch trains were unaffected by the suspension of NB/FR traffic. Average MBTA lateness at Providence (two late trains) crept up from 2:09 minutes to 2:48 minutes. This suggests that Providence services are virtually unaffected by NB/FR traffic.

7.5 ON-TIME PERFORMANCE, DELAY SIMULATED, EVENING PEAK

The following data table displays westbound (peak direction) on-time performance for the delay simulated Year 2010 simulation during the evening peak period. On-time performance at Canton is measured at the new Canton Junction Station, located on the Stoughton Branch. On-time performance at the Attleboro Bypass is measured as the train enters the Bypass.

On-Time Performance at Canton and Providence Stations, and
Attleboro Bypass, Delay Simulated Operations
Peak Direction (Westbound), 4-8 PM
Year 2010 Operations

	On Time/Early	1-10 sec	0:10-1 min	1:01-3 min	3:01-5 min	5:00+	Total
Canton Station							
MBTA	0	0	0	1	2	3	6
Attleboro Bypass							
MBTA	2	0	2	0	1	1	6
Providence Station							
MBTA	1	0	2	1	3	1	8
Amtrak	5	0	1	0	0	0	6

Due to the emphasis on protecting Amtrak's schedules, Amtrak's on-time performance at Providence was affected only by one train twenty-four seconds late. The average westbound MBTA train at Canton Junction was 8:08 minutes late, with the worst case being 18:32 minutes. The system became unstable with the extremely high traffic and could not overcome modest, random station dwell delays. In the westbound direction, delays did not occur because equipment was assumed ready to depart South Station on time. However, westbound trains would be affected by late eastbound trains at the Attleboro Bypass and at Canton Junction. Year 2010 evening operations are somewhat unpredictable; this is partly due to NB/FR trains and partly due to capacity problems that MBTA and Amtrak will have to solve whether NB/FR services operate via Attleboro or not.

7.6 SIGNAL DELAY STATISTICS

Signal delay is a very good measure of the extent of conflicts caused by opposing and following trains operating on rail system. Signal delay minutes were calculated automatically by RAILSIM®. Delays incurred by non-revenue trains, while operating on branch lines, were not included in the totals.

As previously explained, a signal delay is accrued when a train is slowed or stopped by a signal indication. Below are the results for the Year 2010 simulation during the period from 4:00 to 8:00 PM.

The methodology involved running the ideal simulation with and without the NB/FR trains. Results produced total signal delay and the percent changed for each simulation.

Simulation	Total Signal Delay	Percent change
Year 2010, NB/FR suspended	41 minutes 42 seconds	(datum)
Year 2010, all trains	101 minutes 28 seconds	143.3%
Year 2010, delay simulated, all trains	166 minutes 13 seconds	298.6%

The greater number of trains results in an increased level of delay when delay simulation is introduced.

7.8 OPERATIONS IMPACT OF DIESEL MULTIPLE-UNIT EQUIPMENT

A test simulation was performed on the Year 2010 model to determine the compatibility of the ABB IC-3 diesel multiple-unit vehicle with other assumed Year 2010 train operations on the NEC.

As in the Year 2000 simulations, the accompanying table suggests that the IC-3, which has acceleration and braking performance superior to those of the present-day Amtrak Metroliners, enables the NB/FR trains assigned IC-3s to close-in on trains ahead, increasing their own signal delay experience while reducing delay to following trains.

Comparative Signal Delay Results with ABB IC-3 DMU
Revenue Trains, Both Directions, 4-8 PM
Year 2010 Operations

Delay to Simulation	Delay experienced by NB/FR trains	Delay experienced by all other trains	Total Signal Delay
Year 2010 Final	29' 30"	71'58"	101' 28"
Year 2010 IC-3 DMU	57' 59"	58'31"	116' 30"

Operating at 100 mph top normal speed, the IC-3 would be compatible with Year 2010 operations. Its advertised performance exceeds that of the Amtrak Metroliner profile used for MBTA trains in Year 2010. Therefore it should have somewhat better at schedule recovery, road conditions permitting. Signal delay minutes increased slightly (signal delay experienced by the IC-3 due to closing-in on trains ahead was not quite offset by better operation of following trains). With appropriate adjustments to the schedule, it is likely that the net impact would be nil. Schedule recovery capability would still be enhanced, making this operations plan more stable than the previous plans.

8.0 FINDINGS AND CONCLUSIONS

The goal of this project was to determine the feasibility of achieving a level of service of 60 trains per day (with 15 minute peak intervals and 30 minute off-peak intervals between South Station and Taunton, in each direction) to New Bedford/Fall River along the NEC via the Attleboro Bypass. Based on the findings of this study, the planned level of service could not be supported on the NEC via the Attleboro Bypass junction. For New Bedford/Fall River trains, nominal 30 minute peak-period service was achieved and 60 minute off-peak service was achieved.

For the purposes of this study, the extension of New Bedford/Fall River service from the NEC would be made by a double-tracked connection at the Attleboro Bypass junction. This move was made so that westbound diverging and eastbound merging moves could be made in parallel to and from the Bypass. As stated in this report, a single-track design would create an unacceptable bottleneck and preclude the possibility of implementing the MBTA's New Bedford/Fall River (NB/FR) service level goals.

Amtrak's Year 2000 and Year 2010 schedules were successfully implemented into the simulations with minor alterations. Amtrak high-speed trains only experienced delays between Back Bay Station and South Station, while waiting for route-establishments or conflicting traffic.

As noted in this report, Amtrak's high-speed trains will reduce the capacity of the Northeast Corridor. High-speed trains will have shorter point-to-point running times, theoretically improving "throughput". Safe braking criteria for 150 mph operation, results in longer signal control lines. In Year 2000, the problem will be more complex in that Amtrak trains will be capable of obtaining maximum authorized speed (MAS) of 150 mph. MBTA equipment will continue to be only capable of MAS of 80 mph speeds. Negative impacts created by this situation will include: Amtrak overtaking of MBTA trains; longer running times for MBTA trains; and reduced capacity on the NEC over Year 2000.

The Year 2010 simulation indicates that traffic during the evening peak period will be at or near full capacity. Even with infrastructure improvements, careful planning and dispatching will be necessary to avoid serious delays. In the Year 2010, MBTA trains will be capable of obtaining MAS of up to 100 mph. This increase in speed will reduce Amtrak's overtaking of MBTA trains; decrease running times for MBTA trains; and improve capacity on the NEC.

Between Year 2000 and Year 2010, utilize Amtrak services will increase from 34 to 52 trains. MBTA service will consume the remaining available time "slots" and increase from 102 to 122 trains. Planned capacity improvements such as the extension of Track 3 from Transfer Interlocking to a point one mile west of Route 128 Station and reconstruction of Canton Junction will be essential to ensure operating reliability. The greatly increased volume of trains operating on the Northeast Corridor, both Amtrak and MBTA, will no longer permit South Attleboro turn arounds on the main tracks.

This includes both present MBTA practices of either reversing trains at Lawn interlocking or running trains from Attleboro Station to South Attleboro Station via tracks 2 or 4 and having crews change ends at South Attleboro on Track 2. If service cannot be extended, these trains will need to deadhead to Providence to change ends on the commuter platform siding tracks. Similarly, the programmed removal by 2010 of Boro interlocking will not permit turn arounds at Attleboro Station.

In the future, Amtrak will be electrifying its operations between New Haven and Boston. Electrification will affect the operations of service at the Attleboro Bypass. As operations at the Attleboro Bypass junction are critical to the success of New Bedford/Fall River service, the MBTA may consider working with Amtrak to extend electrification for one mile onto the Attleboro Secondary. This could allow for future operations of dual-mode locomotives by the MBTA on the NB/FR lines.

Service requirements for the NB/FR trains, MBTA and Amtrak trains are summarized below:

NEC Operations

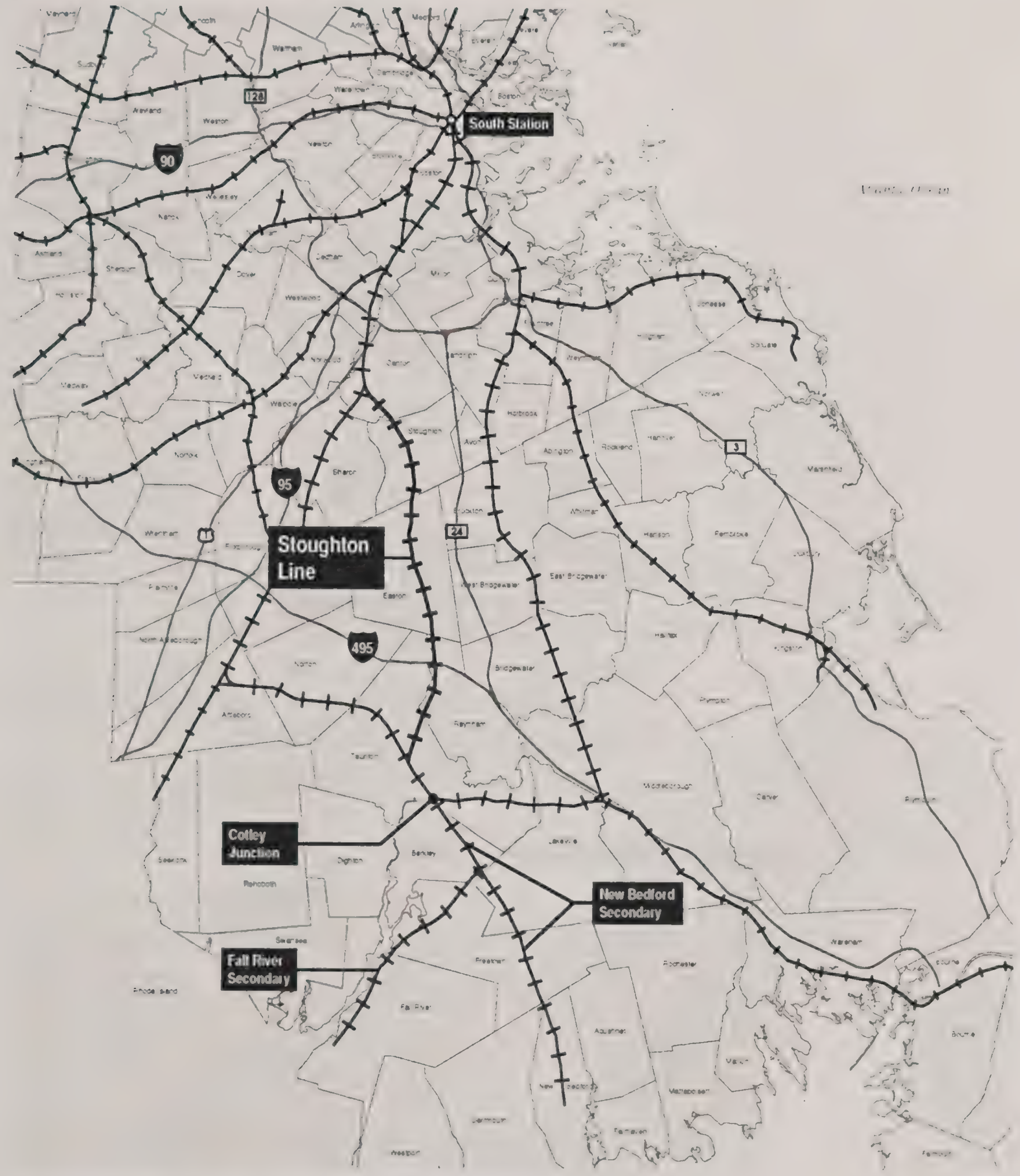
Year	*MBTA Trains*	*NB/FR Trains*	Amtrak Trains	*MBTA MAS*	Amtrak MAS	*MBTA Power*	Amtrak Power
1996	*102*	-	18	*80 MPH*	100 MPH	*Diesel*	Diesel
2000	*102*	*40*	34	*80 MPH*	150 MPH	*Diesel*	Electric
2010	*122*	*44*	52	*100 MPH*	150 MPH	*Diesel* *Electric*	Electric

In summary, the physical plant could not support the MBTA's goal of 60 trains per day via the Northeast Corridor, diverging at a point between Mansfield and Attleboro Stations. This study found that a level of service of 40 to 44 trains could be implemented, while protecting the integrity of existing and future MBTA operations without adverse effects. Careful attention to timetable development and a resolve to implement key capacity improvements based on sound track and signal designs would, however, be critical success factors in its implementation. Future reports are currently planned to analyze New Bedford/Fall River service via the Stoughton and Middleboro Lines of the Old Colony.

Stoughton Branch Operations Simulation April 1999

New Bedford/Fall River
Commuter Rail
EXTENSION PROJECT

STOUGHTON LINE



Massachusetts Bay
Transportation Authority

Operations
Simulation
Report

Technical Report
April 1999

OPERATIONS SIMULATION

OPERATIONS SIMULATION REPORT
New Bedford / Fall River Commuter Rail

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EXECUTIVE SUMMARY

PURPOSE

An operations simulation was conducted for the New Bedford/Fall River Commuter Rail Extension Project from South Station to New Bedford/Fall River by SYSTRA Consulting Inc. (formerly LS Transit Systems) under contract with Vanasse Hagen Brustlin, Inc. (VHB). The purpose of this simulation was to simulate, evaluate and quantify the proposed introduction of MBTA Commuter Rail service to New Bedford and Fall River via Stoughton and Taunton. The focus of this report is to evaluate the segment from Canton Junction to New Bedford and Fall River including impacts to the Northeast Corridor (NEC). The impacts of New Bedford/Fall River service on South Station operations, once fully evaluated, will be included in a separate appendix to this report.

The operations simulation conducted for this report indicates that service could be successfully operated with twenty trips in each direction, each weekday. Half of the trips would originate or terminate at New Bedford and the other half at Fall River. Four peak period trains each will provide service to New Bedford and Fall River during the morning (6 AM – 9AM) and evening (4 PM – 7 PM) peak periods. The remaining trips will operate during off-peak periods. Mid-day operations will provide two-hour service at New Bedford, Fall River and Freetown and will increase service frequencies over today's operations at stations between East Taunton and South Station.

CONSTRAINTS

Proposed service between Canton Junction and New Bedford/Fall River faces several constraints that were addressed in development of the simulation model. Generally, these constraints were:

- Introduction of Amtrak's Northeast Corridor (NEC) High Speed trains in late 1999 or early 2000 – As Amtrak's train speeds increase up to 150 mph, the capacity of the NEC to support following train moves will decrease. A key constraint on the scheduling and operation of the proposed New Bedford and Fall River service is the availability of operating slots or "windows" on the Northeast Corridor between Canton Junction and South Station.

- Environmental constraints - There are several Areas of Critical Environmental Concern (ACEC) between Canton Junction and New Bedford and Fall River. Due to the issues related to environmental permitting required in an ACEC, it was not possible to expand the railroad right-of-way at sections on the corridor, which limited locations for additional tracks or sidings.

- Freight service - It is anticipated that freight service will continue on both the New Bedford and Fall River Branches. So as not to have freight service impact the operations of MBTA service, double track and sidings were provided where possible. However, it was not possible to provide freight operations as part of this simulation.

- Capacity of MBTA layover yards serving South Station - Another key constraint is current yard availability for servicing and laying over of trainsets. The capacities of Readville and Southampton Street facilities are not addressed in this report, but will be evaluated further in a separate appendix.

- MBTA train operations involving any part of the Northeast Corridor presented a particular challenge, requiring development of a substantially new MBTA Commuter Rail service plan for all South Side operations except the Old Colony Lines (Middleboro and Plymouth/Kingston).

ASSUMPTIONS

Several assumptions regarding infrastructure, rolling stock and operations were made to accurately simulate the proposed service of the New Bedford and Fall River Lines. The simulation included planned MBTA and Amtrak capital projects that should be completed by or before 2002. Assumptions for modifications to the infrastructure included:

- Amtrak's installation of 9-Aspect Automatic Train Control/Cab Signal System (ATC/CSS) between Providence and Back Bay (CP-Cove).
- Physical upgrades to numerous Northeast Corridor curves and the historic Canton Viaduct to permit faster operation of Amtrak trains, commencing 4Q 1999 or 1Q 2000.
- Improvements to Canton Junction.
- Relocation of the MBTA layover yard for Providence Line trains from "East Junction" in Attleboro to Pawtucket, Rhode Island.
- Improved diverging speeds into and out of Controlled Passing Sidings located at Attleboro.
- Improvements to CP-Cove (Cove Interlocking, Back Bay) which were recently completed.
- Recent infrastructure changes at South Station, including changes to Tracks 12 and 13.
- Construction and/or rehabilitation of new lines between Canton Junction and Fall River and New Bedford via Myricks Junction.
- Removal of Canton Center Station from service.

Project parameters incorporated into the model, pertaining to the MBTA's facilities and operations, included:

- Turnouts (track switches) to controlled sidings and diverging routes shall be #20 and operated at a maximum speed of 45 miles-per-hour. Exceptions are at Canton Junction, Thrasher Street in Taunton, and the Fall River Branch at Myricks Junction.
- Operation of trains to, from and within yards and sidings will be at a reduced speed appropriate for conditions, typically 10 to 15 mph. Operation of trains between Fall River Station and the proposed Battleship Cove Station will also be at a reduced speed to be determined.
- Overnight layover of trainsets to support Fall River will be at Freetown Yard. Overnight layover of trainsets to support New Bedford will be at New Bedford Yard. All other overnight train storage to support MBTA South Side service will be located at Readville (up to 20 trains) and Southampton Street (up to 4 trains).

- Modifications to the vertical profiles in order to grade-separate rail/roadway intersections, particularly at Route 138 (MP 16.4), were not made as part of the model. For conservatism, a constant upgrade of 1.5% was modeled from Raynham Station to North Easton Station, with the rest of the line south of Canton Junction remaining level.
- Construction of eight new public station stops was considered. Additionally, Fall River and New Bedford trains will provide limited service to Route 128 and Hyde Park and limited service at Ruggles Street. All New Bedford/Fall River trains will stop at Back Bay and South Stations.
- Each MBTA New Bedford / Fall River train consist will include 6 bi-level coaches, equivalent to the presently owned Kawasaki coaches, and one cab control car.

OPERATING PLAN

A comprehensive Operating Plan for South Station was required to support this study. South Station is a vital element of the successful operation of the large traffic volume under consideration – approximately 304 MBTA train movements in or out of South Station every weekday.

Adequate platform space was identified at South Station for all twenty proposed New Bedford and Fall River trains, anticipated Amtrak service, existing Old Colony Line trains (Middleboro and Plymouth/Kingston), and existing and proposed Needham, Franklin, Dorchester and Worcester Line trains. Three peak-period morning slots and three peak-period evening slots were identified for possible future Greenbush Line service. All trains were simulated, including possible future Greenbush Line trains and all supporting Deadhead (non-revenue) trains necessary to ferry trainsets between layover yards at Readville or Southampton Street and South Station.

Rail network simulations for Year 2002 were developed using Systra Consulting's proprietary RAILSIM® Network Simulator, Train Performance Calculator, and *Signal Designer*. The latter software module is an engineering design tool that enables a railroad signal engineer to rapidly develop signal block and signal control line design layouts. It is possible to transfer generated signal block designs into the Network Simulator, which was done in order to model the proposed train control system for the New Bedford/Fall River system extension from Canton Junction. *Signal Designer* requires that an underlying database of the horizontal and vertical profile of the railroad be developed first. Ideally, such a database includes station platform locations and known speed restrictions. This was done using the RAILSIM® Train Performance Calculator and primary source documents such as Valuation Maps and, when available, 10% civil profile drawings. Preliminary station locations between Canton Junction and New Bedford and Fall River were also located.

Beginning with the departure of proposed MBTA Train #617 at 3:05 PM from South Station, the projected evening peak period MBTA service to all *existing* lines plus New Bedford/Fall River will require that 27 trainsets be injected into South Station by 6:30 PM. This is *in addition to* the number of trains already in revenue service to support mid-day schedules, and will empty Readville Yard (20 trainsets) and Southampton Street (4 trainsets). The remaining three trainsets will have to come from additional mid-day revenue trains not presently contemplated and/or from outlying yards further from Boston, such as Providence or Worcester. They may also come from being held in South Station for a protracted mid-day layover (as was done with the equipment for Train #617 – which was held on Track 1 from its arrival as revenue Train 710 at 8:52 AM).

RESULTS

Once a fluid simulation was achieved under deterministic (unperturbed) conditions, the model was subjected to statistical randomization of station dwell times, as well as to the times that trains are initially ready for service at terminal stations. The statistically induced "delays" ranged up to five minutes late for MBTA trains departing from initial terminals and up to ten minutes late for Amtrak trains. Eastbound Amtrak trains could be delayed before reaching Providence and have much longer runs than MBTA trains, hence the more severe induced "delay" for Amtrak trains. Station dwells were statistically likely to be nominally 20 seconds longer in the perturbed model, and could range up to 60 seconds longer.

Perturbed simulation indicated that the Operating Plan tended to be unstable. As expected, there were more conflicts and delays at the busy "Tower 1" (South Station) interlocking that controls train movements through the South Station terminal throat trackage, and more "bump and grind" signal delays on the Northeast Corridor because of sub-optimal train spacing. Signal delay, which is a useful comparative measure of traffic congestion on a rail line, increased by 101% for MBTA revenue trains and by 126% for Amtrak revenue trains on the Northeast Corridor when the model was subjected to the "randomization" or "perturbed" parameters. On-time performance also deteriorated significantly. When the model was subjected to a "severe perturbed" simulation (mimicking very adverse operating conditions such as winter weather), signal delays increased by 214% for MBTA revenue trains and by 238% for Amtrak revenue trains. On-time performance under these conditions was extremely poor, with many trains operating 30 minutes to slightly over one hour late at the extreme.

CONCLUSION

In summary, results of this report's operations simulation indicate that service could be successfully operated with twenty trips in each direction, each weekday. Introduction of MBTA Commuter Rail service to New Bedford and Fall River is operationally feasible, but serious attention should given to the Northeast Corridor infrastructure and operations. The existing and proposed infrastructure can support the operation of these trains to a fair degree of operating reliability when operating conditions are normal and trains are operating on or close to their schedules. Operating reliability and scheduling flexibility could be materially improved by:

Assigning MBTA locomotives equipped with Cab Signal equipment capable of interpreting Amtrak's dual-frequency 9-Aspect Automatic Train Control/Cab Signal System (ATC/CSS) to all Providence, Needham, Fall River and New Bedford Line trains and to those Franklin Line trains that operate on the NEC;

Improving overtake capability/flexibility on the Northeast Corridor. Given the proposed and/or implemented Year 2000-2009 NEC capital program, the only feasible point where Amtrak trains can reliably overtake MBTA trains is at Attleboro. The opportunities to execute peak-period overtakes between Readville and Back Bay are limited because of traffic density on all three main NEC tracks.

PROJECT OVERVIEW

PROJECT HISTORY

Passenger rail service from Boston to New Bedford and Fall River, Massachusetts was historically operated by the New York, New Haven & Hartford Railroad and its predecessor, the Old Colony Railroad[1], via the Boston & Providence Main Line (now known as the Northeast Corridor) and connections at Mansfield and Canton. By 1958, the New Haven Railroad was under extreme financial distress and discontinued most of its remaining commuter train services in southeastern Massachusetts.

In the last decade, interest in restoring service to New Bedford and Fall River has increased. Toward this goal, the Massachusetts Bay Transportation Authority (MBTA) commissioned a feasibility study of commuter rail service to New Bedford and Fall River. The study, *Commuter Rail Extension Feasibility Study - New Bedford/Fall River*, was completed in January 1990 by Louis Berger Associates. The recommendation of the study was that MBTA service be extended to New Bedford and Fall River by utilizing the existing Stoughton Branch, a remnant of a secondary line that extends from Canton Junction through Stoughton to Weir Junction in Taunton. MBTA Commuter Rail service is currently provided only as far as Stoughton.

PHYSICAL DESCRIPTION OF RAIL LINE

Existing Northeast Corridor, South Station to Canton Junction

MBTA Commuter Rail operations share the Northeast Corridor with Amtrak for 43.6 miles from South Station in downtown Boston to Providence, Rhode Island. Three other commuter rail routes use shorter segments of the Corridor. The Stoughton Line branches away 14.8 miles from Boston, the Franklin Line diverges 9.1 miles from Boston and the Needham Line leaves the Corridor 4.4 miles west of Boston. In addition, the Worcester Line operates alongside the Corridor for 1.1 miles between Back Bay Station and South Station. New crossovers installed in recent years in Cove Interlocking east of Back Bay Station enables all of the above train services to use of all tracks between Back Bay and South Station.

---

[1] The original Old Colony Railroad (OCRR) absorbed the Fall River Railroad in 1854. The greater Old Colony Railroad was primarily the result of the combination by 1888 of the Old Colony Railroad, the Boston, Clinton, Fitchburg & New Bedford Railroad and the Boston & Providence Railroad which the OCRR leased from that year. By 1883 the 459-mile Old Colony Railroad was the largest rail system under a single management in the Commonwealth. After 1900, the Old Colony Railroad was operated as an integral part of the New Haven Railroad. (*The Formation of the New England Railroad Systems*, *Baker, Harvard University Press, 1937.)*

The Boston-Providence segment of the Northeast Corridor is a double-track railroad with a passing siding 4.2 miles in length at Attleboro along the eastbound main track only. Between Readville and South Station, a third main track exists for 10.2 miles. The third track, situated to the west of the other two main tracks, is used as a bi-directional track -- inbound trains operate over it during the morning peak period and outbound trains are routed over it during the evening peak. Thus, the railroad east of Readville is operated using a 2-and-1 pattern. That is, two tracks are operated in the peak direction.

All Amtrak trains serving Boston utilize the Northeast Corridor except for those operating via Springfield, Massachusetts on what Amtrak calls its "Inland Route".

Proposed New and Redeveloped Line, Canton Junction to New Bedford and Fall River

The following physical description of the proposed rail line from Canton Junction to New Bedford and Fall River categorically excludes utility sidings (such as maintenance of way pull-offs), freight tracks and industrial spur tracks. Although freight operations and the manner in which they may be conducted in the future is an important element of planning for the proposed MBTA service, the infrastructure elements dedicated solely to freight use are omitted from this narrative and were not part of the operations simulations and analysis.

> **In the narrative that follows and throughout the report, it is important to note the difference between "railroad" direction and compass direction. All trains operating from South Station in Boston toward Fall River or New Bedford are considered westbound, regardless of compass orientation. The physical railroad is oriented such that the general compass direction from Canton Junction toward Fall River and New Bedford is southeasterly. When trains are described as "westbound", they are operating away from Boston; when trains are described as "eastbound", they are operating toward Boston. Moreover, odd numbered trains are "westbound"; even numbered trains are "eastbound".**

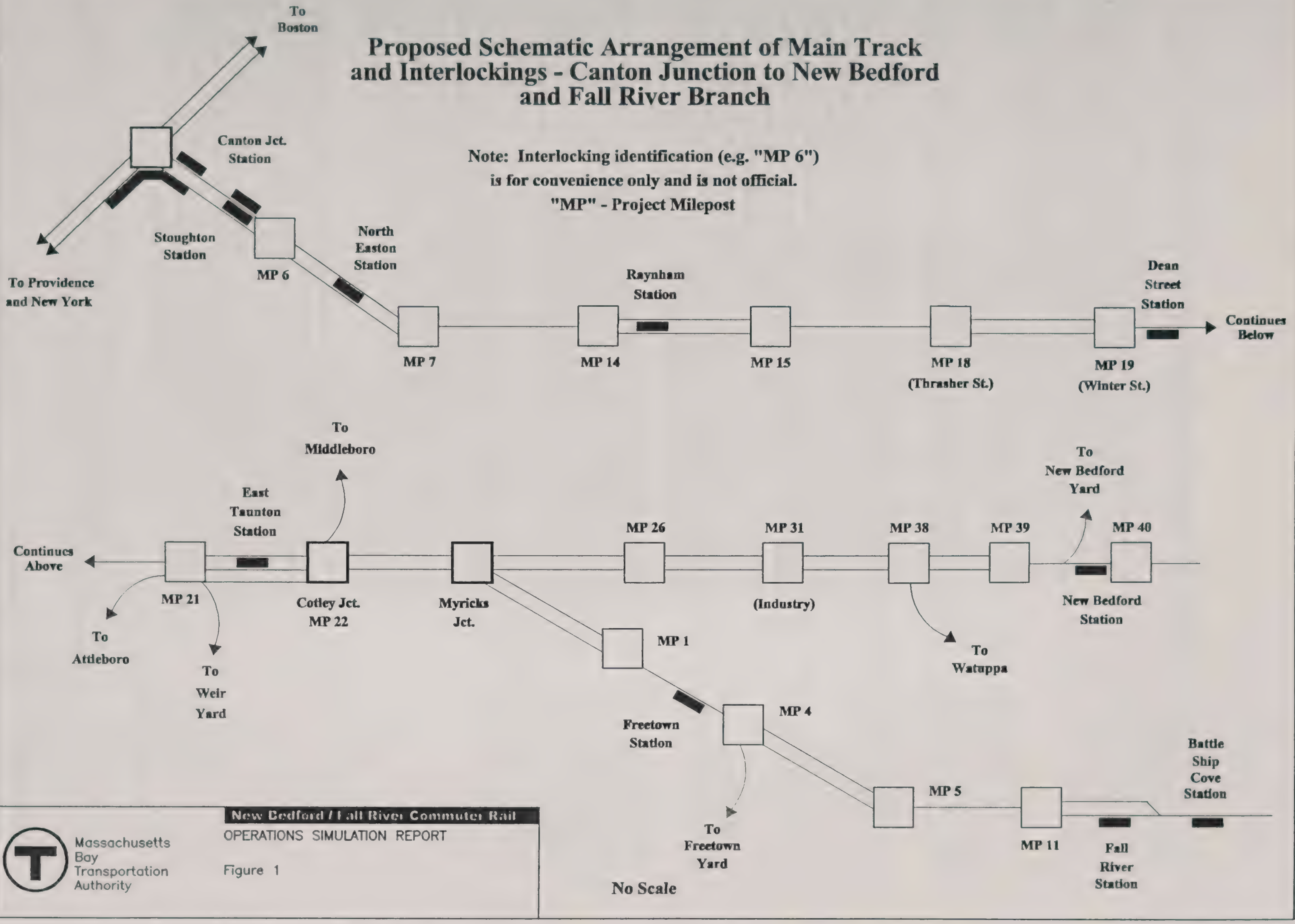
The current proposal contemplates reconstruction of more than fourteen miles of former New York, New Haven & Hartford Railroad track between the existing end-of-track near Milepost 5 (near the Stoughton/Easton Town Line) and Winter Street in Taunton. The remaining track segments between Winter Street in Taunton and Myricks Junction (where branches to New Bedford and to Fall River join) are presently active and are operated by the Bay Colony Railroad Corporation and by Conrail. The New Bedford Secondary is out-of-service through the former railroad yard adjacent to downtown New Bedford (the proposed site of the New Bedford Station); however, a single running track remains physically intact through the site.

In general, the New Bedford Branch consists primarily of double-track right-of-way. The existing freight line, described above, will remain and the MBTA will operate on the proposed westerly track. The Fall River Branch is single track and will have sidings at Myricks, Freetown, and Fall River.

Figure 1 schematically represents the proposed configuration of the railroad connecting the existing MBTA Providence Line/Amtrak Northeast Corridor to Fall River and New Bedford. The proposed alignment begins at Canton Junction, located approximately 15 rail miles west of Boston at Amtrak Milepost 213.9. It is located 3.4 miles west (south) of the Route 128 Station on the MBTA Providence Line/Amtrak Northeast Corridor. The proposed route would utilize the existing Providence Line/Northeast Corridor between South Station in Boston and Canton Junction. **Figure 1** depicts main track only and does not show detail to the level of individual turnouts, crossovers, station platforms or signals. For such detail, the reader is referred to the Single Line Track Chart attached as **Appendix A.**

Proposed Schematic Arrangement of Main Track and Interlockings - Canton Junction to New Bedford and Fall River Branch

Note: Interlocking identification (e.g. "MP 6")
is for convenience only and is not official.
"MP" - Project Milepost



No Scale

Massachusetts Bay Transportation Authority

New Bedford / Fall River Commuter Rail

OPERATIONS SIMULATION REPORT

Figure 1

The route from Canton Junction to New Bedford and Fall River is described as follows:

> Canton Junction is considered Project "Milepost Zero". The junction is to be upgraded to incorporate #20 turnouts (track switches) in a configuration designed to support parallel diverging move capability (i.e., two trains operating in same or opposite directions on adjacent tracks will be able to operate to or from the existing Stoughton Branch simultaneously). The diverging speed is to be 30 mph because of a sharp curve located just west (south) of the Junction. This improvement is already programmed as part of the Northeast Corridor High Speed Rail Electrification Project whether the MBTA's New Bedford/Fall River initiative proceeds or not.
>
> The platforms of Stoughton Station would be shifted slightly, but would still be located approximately at Project Milepost 4 (approximately 19 rail miles from South Station).
>
> From Canton Junction, the route would utilize the existing Stoughton Branch as far as the present end-of-track, just beyond the existing Stoughton Station. From this point south, for a distance of about 14 miles, new railroad would be constructed on an existing railroad grade extending to Winter Street in Taunton. At Winter Street, the railroad would connect with the active track that is currently operated as an industrial switching utility (the Dean Street Industrial Track). It would then continue to Cotley Junction and, ultimately, the New Bedford/Fall River Branches. The railroad would consist of two main tracks from Canton Junction approximately to Milepost 7 in the Town of Easton, where it would revert to a single main track. The proposed North Easton Station would be located along the double-tracked segment. An important Controlled Passing Siding[2] ("Raynham Siding") would be located approximately between Mileposts 14 and 15 in Raynham, which will pass through the proposed site of Raynham Station.
>
> The segment between the north switch of the proposed Raynham Siding and the south limit of the second main track in Easton has been proposed as single track. This is due to environmental permitting issues related to the ACEC District of the Hockomock Swamp. It is recognized that by providing single track, operating flexibility will be reduced through this section. The length of this proposed single-track segment is 34,132 feet (6.5 miles).
>
> The length of proposed single-track segment between the south Point-of-Switch at Raynham Siding and the Point-of-Switch at Thrasher Street is 17,401 feet (3.3 miles). A proposed Controlled Passing Siding would be located between Thrasher and Winter Streets in Taunton. The proposed Dean Street Station would be located adjacent to Route 44 in Taunton near Project Milepost 19.3. A segment of single main track would exist between Winter and Hart streets in Taunton, a distance of 11,395 feet between proposed switchpoints (2.16 miles).
>
> The proposed East Taunton Station would be located approximately at Project Milepost 21.5, within the proposed multiple-track territory to be shared by MBTA and freight operators. The existing Cotley Junction is located approximately at Project Milepost 22 and marks the point where the existing Conrail Middleboro Secondary diverges to that city. The MBTA route to New Bedford and Fall River would proceed straight ahead on the existing Conrail New Bedford Secondary to the site of the existing Myricks Junction, approximately at Project Milepost 25.5. The MBTA would utilize the two main tracks between Hart Street in Taunton and a point just railroad west (compass southeast) of Myricks Junction – a distance of approximately five miles.

---

[2] A Controlled Passing Siding is a meeting point for trains operating in opposite directions in single or multiple-track territory. The limits of the siding are protected by Interlocking (Absolute Stop) signals controlled by a Train Dispatcher or a Block Operator.

The existing Conrail branch lines from Fall River and New Bedford join at Myricks Junction. Myricks Junction would support parallel diverging moves to and from the Fall River Secondary, or a simultaneous train movement along the New Bedford Secondary while another train diverges to or merges from the Fall River Secondary. A Controlled Passing Siding is proposed to be located on the Fall River Secondary from Myricks Junction to a point short of Milepost 1 on the Fall River Branch. All turnouts are proposed to be #20 in order to support merging and diverging speeds of up to 45 miles-per-hour.

The existing single-track New Bedford Secondary continues from Myricks to New Bedford, a distance of approximately 14 miles. The existing single-track Fall River Secondary begins at Myricks Junction and proceeds approximately 11 miles to the site of the proposed Fall River Station and extends approximately one more mile to the proposed Battleship Cove Station. The MBTA will utilize a single main track on each branch.

A Controlled Passing Siding is proposed between Project Mileposts 38 and 39 on the existing New Bedford Secondary, and between Mileposts 4 and 5 on the Fall River Branch.

The proposed Freetown Station would be located immediately to the north (railroad "east") of the north switch of proposed Freetown Siding, near Fall River Secondary Milepost 4.

A proposed layover yard would be located at Freetown near Fall River Branch Milepost 4. Another layover yard would be located on the site of the vacated New Haven Railroad yard at New Bedford, adjacent to the proposed station site.

All MBTA commuter rail operations emanating from South Station, including the proposed New Bedford and Fall River and the proposed train operations of Amtrak post-electrification were analyzed using RAILSIM® Network Simulator. The objective was to measure the ability of the rail system to function successfully and support projected New Bedford and Fall River service. Of particular concern is the impact of the proposed single-track mileage south (railroad "west") of Easton that will inherently limit the ability of trains to meet and pass, and imposes limitations on train scheduling. Also of importance is the imminent start of Amtrak's High Speed Rail service between New York and Boston. These high-priority, high-speed trains must not be delayed and their impending implementation on the railroad presents a scheduling challenge for MBTA commuter rail services.

SIMULATION STUDY LIMITS & ASSUMPTIONS

STUDY LIMITS

A simulation model database of the projected physical plant and signal system configuration, circa 2002, was developed using RAILSIM®. The starting point for this effort was the existing RAILSIM® database that had been developed for the MBTA as part of the previous Expanded Alternatives Analysis. The limits of the simulation model extend from Providence, Rhode Island to South Station, Boston on the Northeast Corridor (NEC). Also included are the existing MBTA Franklin Branch, the Dorchester Branch, the Needham Branch, the operating "Old Colony" lines to Middleboro and Plymouth/Kingston, and a portion of the Worcester Line from Beacon Park Yard (in Allston) to its junction with the NEC at Back Bay (Cove Interlocking). The proposed extension south from Stoughton to Fall River and New Bedford was then added to the model, extending from Canton Junction via Stoughton to Taunton and on to Fall River and New Bedford.

ASSUMPTIONS

Infrastructure

The RAILSIM® model includes planned and approved capital projects, including new rolling stock acquisition by Amtrak, that are expected to be completed by or before 2002. Programmed MBTA and Amtrak capital improvements already committed for the Northeast Corridor between Providence and Boston circa Year 2002 were included in the simulation model. They are:

- 9-Aspect Automatic Train Control/Cab Signal System (ATC/CSS) installed and operational between Providence and Back Bay (CP-Cove), inclusive. It is understood that at least some MBTA trains will *not* be able to interpret all of the new code rates available with this system until sometime after commencement of proposed New Bedford/Fall River service. Accordingly, it had to be assumed that *none* of the MBTA trains will be able to interpret the system. Specifically, this means MBTA trains will interpret CS 80 code as 45 mph instead of 80 mph.

- Physical upgrades to numerous Northeast Corridor curves and the historic Canton Viaduct to permit faster operation of Amtrak trains commencing 4Q 1999 or 1Q 2000, from a proforma list of civil speed restrictions furnished by Amtrak in connection with the New Haven-to-Boston High Speed project. Some locations will have two or even three published speed restrictions that will apply to train type as follows: Amtrak High Speed; Amtrak

"Conventional"[3] and MBTA Commuter. All of this complexity is incorporated into the simulation database.

- Improvements to Canton Junction.
- Relocation of the MBTA layover yard for Providence Line trains from "East Junction" in Attleboro to Pawtucket, Rhode Island.
- Improved diverging speeds into and out of Controlled Passing Sidings located at Attleboro.
- Improvements to CP-Cove (Cove Interlocking, Back Bay) which were recently completed.
- Recent infrastructure changes at South Station, including Tracks 12 and 13.

Certain improvements to public facilities, although important elements of the Northeast Corridor Electrification Project, have no direct bearing on the simulation analysis for the MBTA New Bedford-Fall River initiative and are not specifically identified above. For example, the proposed new station at Route 128 has no direct bearing on the operations analysis.

Infrastructure and station stop assumptions for MBTA facilities were as follows:

- Lines between Canton Junction and Fall River and New Bedford via Myricks Junction will be constructed new or will be substantially rebuilt. Maximum Authorized Speed shall be 70 miles-per-hour. Speed restrictions were calculated for curves by Subconsultant Sverdrup Civil or by VHB based on their likely civil profile and this information was conveyed for incorporation into the simulation database.
- Public station stops from north (east) to south (west):

  Canton Junction (Existing)
  Stoughton (Existing)
  North Easton
  Raynham
  Taunton (Dean Street)
  East Taunton
  Freetown
  Fall River
  New Bedford
  Battleship Cove (off-peak only)

  In addition, Fall River and New Bedford trains will provide limited service to Route 128 and Hyde Park. Fall River and New Bedford trains will provide very limited service to Ruggles Street and none at all during the morning peak period, as approved by MBTA. All trains will stop at Back Bay and South Station.
- Turnouts (track switches) to controlled sidings and diverging routes shall be #20 and operated at a maximum speed of 45 miles-per-hour. There are two exceptions:
  1. Canton Junction, when diverging: 30 mph due to adjacent track curvature
  2. Thrasher Street, Taunton, when westbound diverging: 30 mph due to Safe Braking Distance requirements.
  3. Myricks, when eastbound diverging: 30 mph due to Safe Braking Distance requirements.

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[3] Amtrak "Conventional" service means electric locomotive-hauled trains presumably assigned Amfleet-type coaches.

- An Automatic Train Control and Cab Signal System (ATC/CSS) will exist extending between Canton Junction and Fall River and New Bedford Stations, inclusive. The ATC system will utilize standard code (pulse) rates measured in pulses per minute (ppm):

  180 ppm = Clear, Proceed according to Operating Rules.
  120 ppm = Limited Clear or Approach Limited, 45 mph or as governed by Operating Rules.
  75 ppm = Approach, 30 mph or as governed by Operating Rules.
  No Code = Stop or Restricting, prepared to stop short of obstruction or broken rail.

  The functionality of this system is incorporated in the simulation model.

- The operation of trains to, from and within yards and sidings will be at a reduced speed appropriate for conditions, typically 10 to 15 mph. Operation of trains between Fall River Station and the proposed Battleship Cove Station was assumed to be 25 mph in the simulation.

- Overnight layover of trainsets to support Fall River is assumed to be at Freetown Yard. Overnight layover of trainsets to support New Bedford is assumed to be at New Bedford Yard. All other overnight train storage to support MBTA South Side service is assumed to be located at Readville (up to 20 trains) and Southampton Street (up to 4 trains).

- The vertical profile of the proposed railroad between Stoughton and Fall River and New Bedford has not been fixed and has largely not been modeled. Specifically, severe vertical profile changes involving grades of up to three percent have been proposed in order to grade-separate rail/roadway intersections, especially at Route 138 at Project Milepost 16.4. The vertical profile of the railroad is otherwise undulating with grades of 1.5% or less. Commuter trains, which have a high horsepower-to-trailing-ton ratio typically in excess of 3-to-1, should have little difficulty with short grades of up to one percent under normal operating conditions (absent ice or black rail[4]). However, the line between Taunton and Canton Junction does exhibit uphill gradients toward Boston, some of which exceed one percent. For conservatism, a constant upgrade of 1.5% was modeled from Raynham Station to North Easton Station which *did* affect performance (trains struggled to attain 44 mph). The rest of the railroad in the simulation model south of Canton Junction has been modeled level pending resolution of numerous open issues affecting the vertical profile.

Rolling Stock and Operations

Amtrak operations were simulated according to a 1995 Proforma Operating Plan, furnished by Amtrak. This plan identifies "Day One" High Speed and "Conventional" Amtrak services that will operate between New York City and Boston at the commencement of electrified service to Boston now anticipated for the fourth quarter of 1999 or the first quarter of 2000. This is the same Amtrak Operating Plan that was utilized for the 1996 New Bedford/Fall River commuter rail study that considered access to Taunton via Attleboro. The MBTA directed the Consultant Team to continue to use the 1995 edition of Amtrak's preliminary Northeast Corridor Operating Plan, reflecting electric operation starting in 4Q 1999 or 1Q 2000. Accordingly, this was done and all station stops and timings identified in the 1995 Amtrak Plan were entered into the simulation database. All Amtrak trains in the simulation stop at Back Bay Station despite Amtrak's apparent decision in late 1998 to not serve Back Bay Station with its High Speed trains, at least initially.[5]

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[4] "Black rail" is industry jargon for rail coated with leaves and other vegetation. When the organic material is crushed against the railhead by passing trains, it creates grease-like adhesion conditions.

[5] National Association of Railroad Passengers memo of 31 December 1998 from Ross B. Capon to Mr. George Warrington, CEO, Amtrak and Mr. Stan Bagley, Acting President, Amtrak Northeast Corridor Business Unit.

Equipment

The simulation includes ten high-speed trains and seven "conventional" trains, powered by electric locomotives, on the Northeast Corridor. This includes an overnight sleeper train mimicking Amtrak's existing *Twilight Shoreliner*. This train arrives at South Station just as the morning peak period is getting underway as shown in the model. Similarly, the simulation preserves the operation of Amtrak #12, the "Mail Train", which originates in New York City during the wee hours of the morning and has traditionally arrived in Boston in the late morning. In addition the simulation model retains two Amtrak trains via Framingham and Springfield. One is the traditional *Lake Shore Limited* daily Amtrak service to and from Chicago. This train has traditionally arrived in Boston in the mid to late afternoon and has departed in the early evening. The other, called for in Amtrak's operating plan, runs to New Haven via Springfield.

MBTA equipment, circa 2002, is assumed to be identical to the existing MBTA commuter rail rolling stock fleet. That is, all MBTA trains were assumed to be pulled or pushed by a single 3,000 horsepower, four-axle diesel-electric locomotive such as the "F40" model and its derivatives produced by General Motors Corporation's Electro Motive Division (EMD). The MBTA has recently acquired substantially similar locomotives to support Old Colony service that were remanufactured from the "freight" version of the F40 -- the GP40. These locomotives were equipped at the time of their remanufacture with an auxiliary generator necessary to provide Head End Power.

MBTA trains were assigned single-level coaches consistent with the MBTA's fleet of Bombardier, Pullman-Standard and MBB cars or were assigned Kawasaki bi-level coaches. All trains in the simulation operating to and from New Bedford or Fall River were assigned six Kawasaki bi-level coaches. Every train consist included a cab control coach at the end opposite the locomotive. These vehicles are similar to conventional coaches but have a compartment from which the operator (engineer) controls the train when operating in "push" mode and are heavier than the conventional coaches.

Operations

MBTA train operations involving any part of the Northeast Corridor presented a particular challenge, requiring development of a substantially new MBTA Commuter Rail service plan for all South Side operations except the Old Colony Lines (Middleboro and Plymouth/Kingston). This was necessary because an MBTA South Side Operating Plan circa 2000 was not available. Work on this plan was originally undertaken during a 1996 investigation of proposed operation of New Bedford and Fall River trains via Attleboro. The new MBTA service plan was developed based on the available time "slots" after projected post-1999 Amtrak services, which include High Speed electrified trains between New York and Boston, were programmed into the simulation.

The revamped MBTA "operating plan" includes additional service on the Providence Line already programmed. It also includes twenty trips in each direction serving New Bedford and Fall River. The existing Stoughton Branch service ceases to exist in its present form and is replaced by through trains operating to and from New Bedford and Fall River, providing a net increase in service to Stoughton and Canton Junction. Service at Canton Junction would increase from sixteen[6] frequencies to twenty; service at Stoughton would increase from fifteen frequencies to twenty. Both existing stations would continue to be served by four peak-period, peak-direction schedules each weekday. Proposed service at North Easton Station is very appealing with twenty frequencies, including three peak-period, peak-direction zone express trains offering a nominal 35-minute ride to or from South Station. Canton Junction ceases to be a peak-period station stop on the Northeast Corridor main line and will be served by Fall River and New Bedford trains that will stop on the branch, not on the NEC Main Line.

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[6] Existing Stoughton Branch MBTA schedule; does not include main-line (NEC) service at Canton Junction which is being discontinued.

The MBTA Operating Plan that was developed and simulated, treated existing Old Colony Line services as something of a special case. Trains to and from Middleboro and Plymouth/Kingston were simulated exactly according to the October 26, 1998 public timetable for these two routes without modification of any kind.

The New Bedford/Fall River trains were slotted on the Corridor so as not to interfere with Amtrak trains and to minimize the prospect of interfering with MBTA services on existing routes. Operation of the Northeast Corridor and South Station without incurring *any* signal-system-induced delay to any revenue trains is a physical impossibility because of the rationalized infrastructure of the NEC into Boston. However, an overarching priority was to avoid any interference with Amtrak High Speed revenue trains and to keep interference with *any* Amtrak train to as close to zero as operating practice and physical limitations permitted. Interference with other MBTA trains that would degrade on-time performance under normal operating conditions was also avoided. *The availability of suitable operating "slots" on the Northeast Corridor between South Station and Canton Junction is an important constraint that limits the scheduling flexibility of Fall River and New Bedford train service.* To be successful and acceptable, any proposed Operating Plan must function reliably under normal conditions. Ideally, it should also be able to absorb minor unplanned delays caused by a number of unpredictable factors including equipment malfunctions, tardy passengers, inclement weather and trains that might have been delayed outside of the MBTA's service territory.

The New Bedford/Fall River trains operate to or from each outlying terminal (New Bedford or Fall River) on an alternating basis. Hourly off-peak service on the extensions' trunk (Stoughton to Taunton) is programmed, with two-hour off-peak service on each outlying branch south (railroad "west") of Taunton. A zone express pattern was developed for peak periods in order to avoid redundant stops and to reduce travel time. All trains are programmed to stop at North Easton Station, but peak-period inbound New Bedford trains will skip Stoughton, Canton Junction, Route 128 and Hyde Park. Any inbound passengers boarding at New Bedford requiring transportation to these intermediate stops can board a following Fall River train at North Easton within fifteen to eighteen minutes. Similarly, peak-period inbound Fall River trains will skip East Taunton, Dean Street and Raynham, but *will* stop at stations skipped by the New Bedford trains and will stop at North Easton.

The North Easton Station is expected to experience an increased volume of boardings and alightings due to the proposed peak period zone express service. This was reflected in the operating plan by increasing station dwell times from ninety (90) seconds to a nominal two minutes during peak periods in the peak direction.

Trains operating south of Easton in the simulation were routed through the proposed Raynham passing siding when traveling eastbound *and* stopping at Raynham. Zone express trains *not* stopping at Dean Street in Taunton were deliberately operated via the proposed Winter-thrasher Street siding to ensure reliable signal circuit shunt and daily "exercise" of the turnouts at each end of the siding.

A complete proforma Operating Plan for New Bedford and Fall River service appears on the following page. Off-peak trains operating to Fall River have enough time built into their scheduled layover at Fall River to support potential service to Battleship Cove. Peak-period trains turning at Fall River and New Bedford were programmed with an enforced minimum dwell time of 15 minutes, even if the train arrives late. This ensures adequate time for the train's crew to "change ends" and conduct a terminal brake test.

The New Bedford/Fall River Operating Plan also identifies the disposition of each train's equipment upon reaching Fall River, New Bedford or South Station. Note that some equipment assigned to mid-day schedules makes trips on other MBTA South Side routes after arriving at South Station if there is no logical assignment to another Fall River or New Bedford departure. This is done to maximize equipment utilization and minimize Deadheading. For example, the equipment from the inbound train departing New Bedford at 7:26 AM was programmed to leave South Station as Train #805 to Providence at 8:50 AM (a 14 minute "turn" in South Station). This was done rather than dwell one hour in order to serve as the 9:35 AM departure to Fall River or operate as Deadhead to a layover yard.

The projected New Bedford and Fall River services will require nine trainsets. To support proposed morning peak-period service, four trainsets will be required at Freetown (for Fall River service) and five trainsets will be required at New Bedford to support service from that city. Each night, a like number of trains will terminate at Fall River and New Bedford. Trains terminating at Fall River each evening will operate Deadhead (non-revenue) from Fall River to a proposed layover yard at Freetown. The trainsets assigned to Fall River will operate from Freetown to Fall River Station singly during the early morning hours and enter revenue service at Fall River. It may be desirable to utilize a proposed controlled siding at Fall River Station to "stage" the first two inbound trainsets at Fall River Station each morning. In such a scenario, the first two trainsets would operate from Freetown Yard to Fall River Station during the early morning hours and be held on two adjacent tracks at Fall River Station for their respective departure times.

- Summarizing the number of trainsets needed to support Fall River and New Bedford trains:

Based at Freetown Yard:	4 Trainsets
Based at New Bedford Yard:	5 Trainsets
Presently assigned to Stoughton Line service:	(4 Trainsets[7])
Number of additional consists needed:	**5 Trainsets**

It is not practical to reduce this number by operating additional early morning westbound (outbound) trains from Boston to get additional equipment to Fall River or New Bedford. As a rule of thumb, best running time between Boston (South Station) and Fall River or New Bedford will be approximately 1-1/4 hours (75 minutes). Even if capacity is available on the Northeast Corridor (Providence Line) to operate an early westbound (outbound) train to Fall River or New Bedford, equipment does not become available at South Station under the Operating Plan until approximately 7:20 AM. This is when the equipment from incoming Old Colony Train 004 is programmed to be released empty to the yard. One problem with using this equipment is that it would have trainlined door systems and should stay in service on the Old Colony Line. The other difficulty is that even if this equipment traveled immediately to Fall River or New Bedford, it would arrive after 8:30 AM (assuming no stops). This is too late to supply equipment for an attractive peak-period inbound trip to Boston.

A detailed list of all other revenue MBTA South Side trains programmed into the simulation appears on the following pages:

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[7] Telephone conversation, MBTA Commuter Rail, 13 January 1999.

Table 2

PROFORMA MBTA OPERATING PLAN

Scheduled Arrival and Departure Times at South Station

Providence Line Arrivals		**Providence Line Departures**	
#800	6:40 AM	#803	6:50 AM
#802	7:22 AM	#831	7:50 AM
#804	7:52 AM	#805	8:50 AM
#806	8:16 AM	#807	10:50 AM
#808	8:46 AM	#809	12:50 PM
#810	9:16 AM	#811	2:50 PM
#832	10:02 AM	#813	3:50 PM
#812	11:04 AM	#815	4:37 PM
#814	1:04 PM	#817	5:05 PM
#816	3:04 PM	#819	5:37 PM
#818	5:04 PM	#821	6:10 PM
#820	6:33 PM	#835	6:50 PM
#822	7:33 PM	#823	7:50 PM
#836	8:33 PM	#825	9:50 PM
#824	10:38 PM	#827	11:50 PM
Old Colony Lines Arrivals		**Old Colony Lines Departures**	
#002	6:19 AM	#003	6:45 AM
#032	6:31 AM	#033	7:05 AM
#004	7:05 AM	#005	8:22 AM
#034	7:24 AM	#061	8:50 AM
#006	7:52 AM	#035	9:35 AM
#036	8:06 AM	#007	9:57 AM
#008	8:14 AM	#063	10:50 AM
#038	8:30 AM	#009	11:50 AM
#010	9:00 AM	#039	12:10 PM
#040	9:28 AM	#065	1:20 PM
#012	10:34 AM	#011	2:15 PM
#060	11:00 AM	#041	2:25 PM
#042	11:43 AM	#067	3:00 PM
#014	12:04 PM	#013	3:45 PM
#062	1:05 PM	#043	4:15 PM
#016	1:55 PM	#015	4:45 PM
#044	2:15 PM	#045	4:55 PM
#064	3:20 PM	#017	5:14 PM
#018	4:21 PM	#047	5:30 PM
#048	4:32 PM	#019	5:53 PM
#066	5:30 PM	#049	6:15 PM
#020	5:50 PM	#021	6:45 PM
#022	7:01 PM	#051	7:30 PM
#052	7:25 PM	#023	8:10 PM
#054	8:55 PM	#055	9:30 PM
#024	10:05 PM	#025	10:30 PM
#056	9:45 PM	#057	10:40 PM

Needham Line Arrivals	
#600	6:50 AM
#602	7:30 AM
#604	8:16 AM
#606	8:40 AM
#608	9:11 AM
#610	10:16 AM
#612	11:33 AM
#614	1:33 PM
#616	3:30 PM
#618	4:32 PM
#620	5:50 PM
#622	6:24 PM
#626	7:58 PM
#628	8:36 PM
#630	9:38 PM
#632	10:47 PM

Needham Line Departures	
#605	7:05 AM
#607	7:25 AM
#609	8:40 AM
#611	10:05 AM
#613	12:05 PM
#615	2:05 PM
#617	3:05 PM
#619	4:05 PM
#621	4:55 PM
#623	5:25 PM
#625	5:55 PM
#627	6:25 PM
#629	7:10 PM
#631	8:10 PM
#633	9:15 PM
#635	10:30 PM

Worcester Line Arrivals	
#500	7:02 AM
#552	7:20 AM
#504	7:40 AM
#554	7:50 AM
#556	8:05 AM
#558	8:20 AM
#510	8:44 AM
#562	9:27 AM
#514	10:50 AM
#516	11:50 AM
#518	1:50 PM
#566	3:25 PM
#528	5:20 PM
#522	5:25 PM
#524	6:25 PM
#530	8:05 PM
#532	9:05 PM
#594	10:05 PM
#534	11:05 PM

Worcester Line Departures	
#501	5:20 AM
#503	6:35 AM
#505	7:05 AM
#507	7:35 AM
#509	8:30 AM
#511	10:30 AM
#565	12:30 PM
#515	2:30 PM
#513	3:30 PM
#519	4:30 PM
#571	4:55 PM
#523	5:05 PM
#575	5:25 PM
#595	5:35 PM
#577	6:05 PM
#529	6:15 PM
#579	7:15 PM
#533	8:15 PM
#535	9:15 PM
#537	11:15 PM

Dorchester Line Arrivals	
#744	6:48 AM
#746	7:15 AM
#748	7:50 AM
#750	8:23 AM
#752	8:52 AM
#758	12:38 PM
#762	2:56 PM
#766	4:23 PM
#768	5:30 PM
#770	5:58 PM
#772	6:26 PM
#774	6:56 PM
#776	7:31 PM

Dorchester Line Departures	
#749	7:30 AM
#707	9:20 AM
#709	11:34 AM
#763	3:06 PM
#767	4:03 PM
#737	4:40 PM
#769	5:06 PM
#771	5:36 PM
#773	6:11 PM
#775	7:05 PM
#781	9:25 PM

Franklin Line Arrivals	
#790	6:20 AM
#702	6:48 AM
#704	7:15 AM
#708	7:50 AM
#738	8:23 AM
#710	8:52 AM
#792	9:27 AM
#712	10:22 AM
#714	11:28 AM
#716	1:46 PM
#718	4:12 PM
#720	8:13 PM
#722	9:22 PM
#724	10:32 PM
#726	11:38 PM

Franklin Line Departures	
#793	7:00 AM
#735	8:02 AM
#799	8:15 AM
#755	10:25 AM
#759	12:45 PM
#711	1:55 PM
#715	4:03 PM
#717	4:40 PM
#719	5:06 PM
#721	5:36 PM
#723	6:11 PM
#725	8:20 PM
#729	10:45 PM
#731	11:40 PM

SOURCES OF TECHNICAL DATA

The following source documents were utilized to develop and refine the RAILSIM® simulation models. This list is not all-inclusive; additional sources of information, including input from the MBTA and other consulting firms in the Project Team contributed information and advice to the simulation modeling effort.

- Amtrak Northeast Corridor Employees Timetable No. 2 Effective 12:01 AM April 5, 1998.
- Amtrak MBTA Employees Timetable, July, 1997, with revisions of 9-29-97.
- Amtrak Track Charts, "Proposed High Speed Configuration, 'Shore Line' New Haven to Boston", January 1, 1996.
- 9-Aspect Cab Signal System, Signal Control Line drawings for the Northeast High-speed Rail Improvement Project, New Haven to Boston; Amtrak P.I., LS Transit Systems, Inc.
- Amtrak "Canton Junction Interlocking, Signal Aspects," July 25, 1994
- Amtrak "Transfer, Read Interlockings, Signal Aspects," December 9, 1993
- List of (planned) civil speed restrictions, New Haven to Boston, Northeast High-speed Rail Improvement Project, for Amtrak "high-speed" and “conventional” operations, as of 1/96.
- Memorandum from MBTA Railroad Operations delineating a list of South Attleboro trains to be extended to Providence upon completion of Pawtucket Yard.
- Amtrak "Draft Amtrak 2000 Service", Boston to New York ("For Planning Purposes Only"), as of 1995.
- USRA Valuation Maps, various, Stoughton Junction (site) to Weir Junction, circa 1918, as revised through January 26, 1973.
- 10% Horizontal and Vertical Civil Profile Drawings, New Bedford Branch and Fall River Branch, Vanasse Hangen Brustlin, Inc./Sverdrup Civil, Inc., November 1995.
- 10% Horizontal and Vertical Civil Profile Drawings, various, Stoughton to Taunton, Sverdrup Civil, Inc., December 1998 and subsequent refinements.
- Predicted Speed Restrictions, Stoughton to Taunton and Taunton to Fall River and New Bedford, respectively, supplied by VHB December 1998 and January 1999.
- New Bedford/Fall River Commuter Rail Project Report, VHB, September 11, 1995.
- “60% Submittal” civil layout drawing of proposed Myricks Junction, no date, not approved, incomplete title block, received from Vanasse Hangen Brustlin, Inc. by transmittal dated December 30, 1998.

SIMULATION CALIBRATION

To be credible, a simulation model must be calibrated to demonstrate its accurate representation of real world rail operations. Calibration requires collecting signal clearing times (the time required for an Automatic Block Signal or Cab Signal code rate to restore to Clear or best aspect after passage of a train) at selected locations. It also involves riding trains to collect point-to-point running time and station dwell time data samples. Typically, a threshold correlation of simulated operation to within 10% of observed (field) operations is considered highly credible given day-to-day variations in train performance and weather conditions.

The original RAILSIM® network simulation model developed for the MBTA simulated existing (1995) Amtrak and MBTA operations and was calibrated to actual rolling stock and signal system performance. The excellent results were published in Technical Report No. 6 of the North-South Rail Link Project, *Commuter Rail RAILSIM® Operations Simulation Report* (February, 1996). The project team has not been advised of any material change in MBTA commuter train acceleration or braking performance since that time. Accordingly, the 1995-96 calibration exercise shall serve as verification that the RAILSIM® model represents fairly and accurately the operation of MBTA and conventional (diesel-hauled) Amtrak trains and the signal systems in place at that time.

Similarly, Amtrak conventional electric locomotive-hauled performance calibration has been repeatedly verified by simulations involving Amtrak's Northeast Corridor west of Penn Station New York, where simulation experience reaches back to 1992.

Equipment that does not exist at this writing, in particular the High Speed "American Flyer" trainsets under construction by Bombardier Corporation, cannot be observed. In this case, the published preliminary performance specifications of these trainsets were used to develop acceleration and braking profiles for simulation purposes. There can be no assurance that the actual trainsets, once in service, will perform identically in step with the proforma specifications. However, simulation modeling tends to be conservative and on this basis and on repeated highly-accurate simulations of electric Amtrak trains operating between New York and Washington, it is believed that the simulation of the proposed High Speed trainsets is a fair representation of likely actual performance capabilities.

Similarly, it is axiomatic that infrastructure that does not exist cannot be observed. This applies to the entire proposed railroad between Canton Junction and Fall River and New Bedford. The railroad between these points will be completely reconstructed. Although the general horizontal and vertical profile is documented to the 10% level, important elements such as the signal system, grade crossings and exact station platform locations are not yet precisely defined and do not exist. Therefore, the simulation serves as a *predictor* of likely New Bedford and Fall River train service performance given assumptions such as:

- Maximum operating speed (70 mph) and civil speed restrictions

- Station stops and stopping pattern
- Likely or anticipated station dwell times given Kawasaki bi-level cars to be used, extent of high-level station platforms (which speed boarding) and ridership demand
- Other Northeast Corridor traffic unrelated to New Bedford and Fall River service.

ANALYSIS AND RESULTS

Two types of conventional quantitative analyses were undertaken with the operating simulation model – *on-time performance* and *signal delay*. On-time performance measures whether trains arrived or left late, on-time or early relative to the intended schedule or Operating Plan. On-time performance represents a measure of service quality observed by the public. The public does not necessarily know that a schedule may allow a certain amount of "recovery" time to overcome a delay en route and still arrive at destination "on time". Patrons will perceive that their train is "late" if it does not arrive or depart when the published schedule says it should. This is "on time performance" and is the measure of "delay" as it is perceived by the public.

Signal delay is a supporting quantitative measure that provides a comparative indicator of the degree of traffic congestion on a rail line, relative to the capacity of its infrastructure. When more trains are operated over a line in a fixed period of time than the signal system was designed to support, signal delays will accrue because following trains will not receive Clear signals. They will receive something more restrictive than Clear that will cause their operators to slow down or even stop because of traffic ahead. Even so, a schedule can be designed with so much "pad" that these trains, however much delayed by restrictive signals, still arrive "on time". Comparing signal delay statistics under deterministic (unperturbed) conditions and then under perturbed conditions for the same infrastructure and Operating Plan provides insight into whether or not the network is stressed by the perturbation. If train operations recover quickly from day-to-day variations in train performance and minor random delays, the Operating Plan is probably sound and this will be reflected by little change in accrued signal delay or even a reduction. And visa versa.

A randomized (perturbed) simulation analysis was performed on the simulation model to evaluate the stability of the schedule under realistic conditions. Perturbed simulation analysis mimics real-world terminal departure delays and intermediate station dwell delays. Large changes in on-time performance and signal delay minutes in response to small perturbations (statistically controlled delay events) usually indicate a fragile Operating Plan that would potentially have difficulty overcoming minor challenges. On the other hand, a railroad operation that exhibits an ability to recover from real-world fluctuations in performance without a tendency toward cascading delays is likely to be viable under actual conditions. In New England, winter weather is typically the most severe test of an operating plan.

ON-TIME PERFORMANCE

On-time performance was measured at South Station for eastbound trains and at Providence, Needham, Franklin, Plymouth, Kingston, Middleboro, Fall River and New Bedford for westbound trains. Westbound Amtrak performance was measured only at Providence (the limit of the study territory) because Amtrak does not serve any of the other terminal stations listed. Amtrak and MBTA trains leaving South Station for the Worcester Line were monitored at Back Bay Station.

The following tables display on-time performance for the ***deterministic*** (unperturbed) simulation. Where trains are late even in the deterministic model, it indicates that scheduled running time may be inadequate and before service is implemented, schedules should be adjusted (a process sometimes called "tweaking"). For example, in the lateness distribution below for Fall River, trains arriving from Boston are as much as three minutes late. This is minor for a railroad that has not even been designed to the 100% level. However, it illustrates the point. In a few (isolated) cases, trains were egregiously late such as MBTA Train 819 that finally arrived at Providence Station more than 15 minutes late because of traffic on the Northeast Corridor. This should be considered unacceptable as a planned operation and this train will have to be rescheduled when more current information is available about Amtrak's "Day One" Operating Plan for its High Speed Rail Service to Boston.

Table 3

```
Lateness Report  (Deterministic simulation)
Station: FALL RIVER
Lateness distribution:           Cnt     Pct.    Cum    Pct.

                              -------- Westbound only --------
5:01 or more minutes early        0      0.0       0     0.0
4:01 - 5:00 minutes early         0      0.0       0     0.0
3:01 - 4:00 minutes early         0      0.0       0     0.0
2:01 - 3:00 minutes early         0      0.0       0     0.0
1:01 - 2:00 minutes early         0      0.0       0     0.0
0:01 - 1:00 minutes early         0      0.0       0     0.0
On time                           0      0.0       0     0.0
0:01 - 1:00 minutes late          4     40.0       4    40.0
1:01 - 2:00 minutes late          5     50.0       9    90.0
2:01 - 3:00 minutes late          1     10.0      10   100.0
3:01 - 4:00 minutes late          0      0.0      10   100.0
4:01 - 5:00 minutes late          0      0.0      10   100.0
5:01 - 6:00 minutes late          0      0.0      10   100.0
6:01 - 7:00 minutes late          0      0.0      10   100.0
7:01 - 8:00 minutes late          0      0.0      10   100.0
8:01 - 9:00 minutes late          0      0.0      10   100.0
9:01 - 10:00 minutes late         0      0.0      10   100.0
10:01 or more minutes late        0      0.0      10   100.0

Total lateness, all trains       10                    11:03
Average lateness, all trains     10                    01:07
Average lateness, late trains    10                    01:07
Latest Train:      923                                 02:28
```

Table 4

```
Lateness Report  (Deterministic simulation)
Station: NEW BEDFORD
Lateness distribution:              Cnt     Pct.     Cum    Pct.

                                 -------- Westbound only --------
5:01 or more minutes early           0      0.0        0     0.0
4:01 - 5:00 minutes early            0      0.0        0     0.0
3:01 - 4:00 minutes early            0      0.0        0     0.0
2:01 - 3:00 minutes early            0      0.0        0     0.0
1:01 - 2:00 minutes early            0      0.0        0     0.0
0:01 - 1:00 minutes early            0      0.0        0     0.0
On time                              1     10.0        1    10.0
0:01 - 1:00 minutes late             1     10.0        2    20.0
1:01 - 2:00 minutes late             5     50.0        7    70.0
2:01 - 3:00 minutes late             0      0.0        7    70.0
3:01 - 4:00 minutes late             1     10.0        8    80.0
4:01 - 5:00 minutes late             1     10.0        9    90.0
5:01 - 6:00 minutes late             1     10.0       10   100.0
6:01 - 7:00 minutes late             0      0.0       10   100.0
7:01 - 8:00 minutes late             0      0.0       10   100.0
8:01 - 9:00 minutes late             0      0.0       10   100.0
9:01 - 10:00 minutes late            0      0.0       10   100.0
10:01 or more minutes late           0      0.0       10   100.0

Total lateness, all trains          10                      21:13
Average lateness, all trains        10                      02:08
Average lateness, late trains        9                      02:22
Latest Train:        879                                    05:16
```

Table 5

```
Lateness Report  (Deterministic simulation)
Station: PROVIDENCE
Lateness distribution:              Cnt     Pct.     Cum    Pct.

                                 -------- Westbound only --------
5:01 or more minutes early           0      0.0        0     0.0
4:01 - 5:00 minutes early            1      4.0        1     4.0
3:01 - 4:00 minutes early            0      0.0        1     4.0
2:01 - 3:00 minutes early            0      0.0        1     4.0
1:01 - 2:00 minutes early            0      0.0        1     4.0
0:01 - 1:00 minutes early            1      4.0        2     8.0
On time                             13     52.0       15    60.0
0:01 - 1:00 minutes late             3     12.0       18    72.0
1:01 - 2:00 minutes late             2      8.0       20    80.0
2:01 - 3:00 minutes late             1      4.0       21    84.0
3:01 - 4:00 minutes late             1      4.0       22    88.0
4:01 - 5:00 minutes late             1      4.0       23    92.0
5:01 - 6:00 minutes late             0      0.0       23    92.0
6:01 - 7:00 minutes late             0      0.0       23    92.0
7:01 - 8:00 minutes late             1      4.0       24    96.0
8:01 - 9:00 minutes late             0      0.0       24    96.0
9:01 - 10:00 minutes late            0      0.0       24    96.0
10:01 or more minutes late           1      4.0       25   100.0

Total lateness, all trains          25                      31:25
Average lateness, all trains        25                      01:16
Average lateness, late trains       10                      03:39
Latest Train:        819                                    15:06
```

Table 6

```
Lateness Report  (Deterministic simulation)
Station: NEEDHAM HEIGHTS
Lateness distribution:            Cnt     Pct.    Cum    Pct.

                               -------- Westbound only --------
5:01 or more minutes early          0     0.0       0     0.0
4:01 - 5:00 minutes early           0     0.0       0     0.0
3:01 - 4:00 minutes early           0     0.0       0     0.0
2:01 - 3:00 minutes early           0     0.0       0     0.0
1:01 - 2:00 minutes early           0     0.0       0     0.0
0:01 - 1:00 minutes early           0     0.0       0     0.0
On time                             9    56.3       9    56.3
0:01 - 1:00 minutes late            3    18.8      12    75.0
1:01 - 2:00 minutes late            3    18.8      15    93.8
2:01 - 3:00 minutes late            0     0.0      15    93.8
3:01 - 4:00 minutes late            1     6.3      16   100.0
4:01 - 5:00 minutes late            0     0.0      16   100.0
5:01 - 6:00 minutes late            0     0.0      16   100.0
6:01 - 7:00 minutes late            0     0.0      16   100.0
7:01 - 8:00 minutes late            0     0.0      16   100.0
8:01 - 9:00 minutes late            0     0.0      16   100.0
9:01 - 10:00 minutes late           0     0.0      16   100.0
10:01 or more minutes late          0     0.0      16   100.0

Total lateness, all trains         16                  09:16
Average lateness, all trains       16                  00:35
Average lateness, late trains       7                  01:20
Latest Train:       623                                03:36
```

Table 7

```
Lateness Report  (Deterministic simulation)
Station: FRANKLIN
Lateness distribution:            Cnt     Pct.    Cum    Pct.

                               -------- Westbound only --------
5:01 or more minutes early          0     0.0       0     0.0
4:01 - 5:00 minutes early           0     0.0       0     0.0
3:01 - 4:00 minutes early           0     0.0       0     0.0
2:01 - 3:00 minutes early           0     0.0       0     0.0
1:01 - 2:00 minutes early           0     0.0       0     0.0
0:01 - 1:00 minutes early           0     0.0       0     0.0
On time                             4    25.0       4    25.0
0:01 - 1:00 minutes late            4    25.0       8    50.0
1:01 - 2:00 minutes late            3    18.8      11    68.8
2:01 - 3:00 minutes late            2    12.5      13    81.3
3:01 - 4:00 minutes late            0     0.0      13    81.3
4:01 - 5:00 minutes late            0     0.0      13    81.3
5:01 - 6:00 minutes late            1     6.3      14    87.5
6:01 - 7:00 minutes late            0     0.0      14    87.5
7:01 - 8:00 minutes late            1     6.3      15    93.8
8:01 - 9:00 minutes late            1     6.3      16   100.0
9:01 - 10:00 minutes late           0     0.0      16   100.0
10:01 or more minutes late          0     0.0      16   100.0

Total lateness, all trains         16                  33:16
Average lateness, all trains       16                  02:05
Average lateness, late trains      12                  02:47
Latest Train:       721                                08:12
```

Table 8

```
Lateness Report  (Deterministic simulation)
Station: PLYMOUTH
Lateness distribution:              Cnt     Pct.    Cum    Pct.

                                 -------- Westbound only --------
5:01 or more minutes early            0      0.0      0     0.0
4:01 - 5:00 minutes early             0      0.0      0     0.0
3:01 - 4:00 minutes early             0      0.0      0     0.0
2:01 - 3:00 minutes early             0      0.0      0     0.0
1:01 - 2:00 minutes early             0      0.0      0     0.0
0:01 - 1:00 minutes early             0      0.0      0     0.0
On time                               2     50.0      2    50.0
0:01 - 1:00 minutes late              1     75.0      3    75.0
1:01 - 2:00 minutes late              0      0.0      3    75.0
2:01 - 3:00 minutes late              0      0.0      3    75.0
3:01 - 4:00 minutes late              1    100.0      4   100.0
4:01 - 5:00 minutes late              0      0.0      4   100.0
5:01 - 6:00 minutes late              0      0.0      4   100.0
6:01 - 7:00 minutes late              0      0.0      4   100.0
7:01 - 8:00 minutes late              0      0.0      4   100.0
8:01 - 9:00 minutes late              0      0.0      4   100.0
9:01 - 10:00 minutes late             0      0.0      4   100.0
10:01 or more minutes late            0      0.0      4   100.0

Total lateness, all trains            4                    03:40
Average lateness, all trains          4                    01:51
Average lateness, late trains         2                    01:51
Latest Train:       067                                    03:31
```

Table 9

```
Lateness Report (Deterministic simulation)
Station: KINGSTON
Lateness distribution:              Cnt     Pct.    Cum    Pct.

                                 -------- Westbound only --------
5:01 or more minutes early            0      0.0      0     0.0
4:01 - 5:00 minutes early             0      0.0      0     0.0
3:01 - 4:00 minutes early             0      0.0      0     0.0
2:01 - 3:00 minutes early             0      0.0      0     0.0
1:01 - 2:00 minutes early             0      0.0      0     0.0
0:01 - 1:00 minutes early             0      0.0      0     0.0
On time                               1      9.1      1     9.1
0:01 - 1:00 minutes late              3     27.2      4    36.4
1:01 - 2:00 minutes late              0      0.0      4    36.4
2:01 - 3:00 minutes late              1      9.1      5    45.5
3:01 - 4:00 minutes late              2     15.4      7    63.6
4:01 - 5:00 minutes late              1      9.1      8    72.7
5:01 - 6:00 minutes late              1      9.1      9    81.8
6:01 - 7:00 minutes late              0      0.0      9    81.8
7:01 - 8:00 minutes late              1      9.1     10    90.9
8:01 - 9:00 minutes late              0      0.0     10    90.9
9:01 - 10:00 minutes late             0      0.0     10    90.9
10:01 or more minutes late            1      9.1     11   100.0

Total lateness, all trains           11                    39:24
Average lateness, all trains         11                    03:02
Average lateness, late trains        10                    03:57
Latest Train:       047                                    11:24
```

Table 10

```
Lateness Report  (Deterministic simulation)
Station: MIDDLEBORO/LAKEVILLE
Lateness distribution:            Cnt     Pct.    Cum    Pct.

                              -------- Westbound only --------
5:01 or more minutes early          0      0.0      0     0.0
4:01 - 5:00 minutes early           0      0.0      0     0.0
3:01 - 4:00 minutes early           0      0.0      0     0.0
2:01 - 3:00 minutes early           0      0.0      0     0.0
1:01 - 2:00 minutes early           0      0.0      0     0.0
0:01 - 1:00 minutes early           0      0.0      0     0.0
On time                             8     66.7      8    66.7
0:01 - 1:00 minutes late            2     16.7     10    83.3
1:01 - 2:00 minutes late            1      8.3     11    91.7
2:01 - 3:00 minutes late            1      8.3     12   100.0
3:01 - 4:00 minutes late            0      0.0     12   100.0
4:01 - 5:00 minutes late            0      0.0     12   100.0
5:01 - 6:00 minutes late            0      0.0     12   100.0
6:01 - 7:00 minutes late            0      0.0     12   100.0
7:01 - 8:00 minutes late            0      0.0     12   100.0
8:01 - 9:00 minutes late            0      0.0     12   100.0
9:01 - 10:00 minutes late           0      0.0     12   100.0
10:01 or more minutes late          0      0.0     12   100.0

Total lateness, all trains         12                    04:22
Average lateness, all trains       12                    00:22
Average lateness, late trains       4                    01:06
Latest Train:       009                                  02:03
```

Table 11

```
Lateness Report (Deterministic simulation)
Station: BACK BAY (B&A Side)
Lateness distribution:            Cnt     Pct.    Cum    Pct.
                                -------- Westbound only --------
5:01 or more minutes early          0      0.0      0     0.0
4:01 - 5:00 minutes early           0      0.0      0     0.0
3:01 - 4:00 minutes early           0      0.0      0     0.0
2:01 - 3:00 minutes early           0      0.0      0     0.0
1:01 - 2:00 minutes early           0      0.0      0     0.0
0:01 - 1:00 minutes early           0      0.0      0     0.0
On time                            19     86.4     19    86.4
0:01 - 1:00 minutes late            3     13.6     22   100.0
1:01 - 2:00 minutes late            0      0.0     22   100.0
2:01 - 3:00 minutes late            0      0.0     22   100.0
3:01 - 4:00 minutes late            0      0.0     22   100.0
4:01 - 5:00 minutes late            0      0.0     22   100.0
5:01 - 6:00 minutes late            0      0.0     22   100.0
6:01 - 7:00 minutes late            0      0.0     22   100.0
7:01 - 8:00 minutes late            0      0.0     22   100.0
8:01 - 9:00 minutes late            0      0.0     22   100.0
9:01 - 10:00 minutes late           0      0.0     22   100.0
10:01 or more minutes late          0      0.0     22   100.0

Total lateness, all trains         22                    02:03
Average lateness, all trains       22                    00:06
Average lateness, late trains       3                    00:41
Latest Train:       571                                  00:52
```

The final table, below, displays on-time performance for all trains arriving at South Station in simulation – Amtrak and MBTA. Note that the average lateness of 88 "late" trains was only 1 minute 55 seconds, which is excellent considering the volume of traffic handled. One existing Old Colony train, #044, was 6 minutes 15 seconds late due to a delayed meet with an opposing train. Another nine trains were more than four minutes late but not more than six minutes late.

Table 12

```
Lateness Report (Deterministic simulation)
Station: SOUTH STATION
Lateness distribution:            Cnt     Pct.     Cum     Pct.
                                 -------- Eastbound only --------
5:01 or more minutes early         1      0.7        1     0.7
4:01 - 5:00 minutes early          0      0.0        1     0.7
3:01 - 4:00 minutes early          1      0.7        2     1.4
2:01 - 3:00 minutes early          4      2.7        6     4.1
1:01 - 2:00 minutes early         20     13.6       26    17.7
0:01 - 1:00 minutes early         31     21.1       57    38.8
On time                            2      1.4       59    40.1
0:01 - 1:00 minutes late          32     21.8       91    61.9
1:01 - 2:00 minutes late          21     14.3      112    76.2
2:01 - 3:00 minutes late          14      9.5      126    85.7
3:01 - 4:00 minutes late          11      7.5      137    93.2
4:01 - 5:00 minutes late           6      4.1      143    97.3
5:01 - 6:00 minutes late           3      2.0      146    99.3
6:01 - 7:00 minutes late           1      0.7      147   100.0
7:01 - 8:00 minutes late           0      0.0      147   100.0
8:01 - 9:00 minutes late           0      0.0      147   100.0
9:01 - 10:00 minutes late          0      0.0      147   100.0
10:01 or more minutes late         0      0.0      147   100.0

Total lateness, all trains       147                   1:45:00
Average lateness, all trains     147                     00:43
Average lateness, late trains     88                     01:55
Latest Train:       044                                  06:15
```

The following tables display on-time performance for the ***perturbed*** simulation in which MBTA trains and Amtrak trains were subjected to randomly early or late starts and to random statistical variations in dwell times at intermediate stations. To wit,

- Terminal departure times, MBTA: from 2 minutes "early" to 5 minutes late, mean 75 seconds late and Standard Deviation 2 minutes.

- Terminal departure times, Amtrak: from 2 minutes "early" to 10 minutes late, mean 75 seconds late and Standard Deviation 2 minutes.

- Intermediate station dwells: from 10 seconds shorter to 60 seconds longer, mean 20 seconds longer, Standard Deviation 10 seconds.

These statistical profiles were not provided by the Client or other interested parties, but were developed through the extensive simulation experience of the Project Team on other similar properties. The key is not whether the perturbations applied to the model exactly mimic what is thought to be "typical" experience, but rather what happens to the simulation results when reasonable delays are introduced in a statistically controlled manner. For example, the statistical profile applied to intermediate station dwell times was such that trains were statistically *likely* to spend an additional twenty seconds at each station stop. The results of the perturbed simulation indicate whether this phenomenon as well as the statistical probability of late starts (up to five minutes late for MBTA, up to ten minutes for Amtrak) materially affects the operational reliability of the railroad.

"Cascading" delays occur when a trainset arrives late at South Station and then leaves late, out-of-slot. The most serious problem caused by out-of-slot trains is delay to Amtrak trains when either an Amtrak or an MBTA train (or both) is late causing Amtrak to closely follow an MBTA train along the Northeast Corridor/Providence Line with no opportunity for an overtake except at Attleboro. Overtakes between Readville and Back Bay are not feasible during peak period operations due to intense traffic on all three tracks between these points. It will be observed that some trains arrive very late at destination terminals even though the perturbation applied to the model was modest. For example, Train 923 is a proposed Fall River train that is scheduled to depart South Station at 6:20 PM. Due to cascading delays, it left South Station 15:39 late in this particular perturbed simulation. It lost another 9 minutes 50 seconds en route to Canton Junction since it operated out-of-slot on the Corridor (hence 25:19 late at that point). The train was unable to recover its schedule even though it lost no additional time between Canton Junction and Fall River (actually recovering slightly to 23:58 late.)

Note that the simulation database enforces a minimum ten-minute MBTA turn time at South Station and a minimum 15 or 20 minute Amtrak turn time. Trains departing South Station do not leave early.

Table 13

```
Lateness Report (Perturbed simulation)
Station: FALL RIVER
Lateness distribution:             Cnt      Pct.     Cum     Pct.

                                -------- Westbound only --------
5:01 or more minutes early           0      0.0        0      0.0
4:01 - 5:00 minutes early            0      0.0        0      0.0
3:01 - 4:00 minutes early            0      0.0        0      0.0
2:01 - 3:00 minutes early            0      0.0        0      0.0
1:01 - 2:00 minutes early            0      0.0        0      0.0
0:01 - 1:00 minutes early            0      0.0        0      0.0
On time                              0      0.0        0      0.0
0:01 - 1:00 minutes late             2     20.0        2     20.0
1:01 - 2:00 minutes late             2     20.0        4     40.0
2:01 - 3:00 minutes late             1     10.0        5     50.0
3:01 - 4:00 minutes late             0      0.0        5     50.0
4:01 - 5:00 minutes late             0      0.0        5     50.0
5:01 - 6:00 minutes late             0      0.0        5     50.0
6:01 - 7:00 minutes late             0      0.0        5     50.0
7:01 - 8:00 minutes late             0      0.0        5     50.0
8:01 - 9:00 minutes late             1     10.0        6     60.0
9:01 - 10:00 minutes late            0      0.0        6     60.0
10:01 or more minutes late           4     40.0       10    100.0

Total lateness, all trains          10                    1:23:39
Average lateness, all trains        10                      08:22
Average lateness, late trains       10                      08:22
Latest Train:      923                                      23:58
```

Table 14

```
Lateness Report (Perturbed simulation)
Station: NEW BEDFORD
Lateness distribution:              Cnt     Pct.    Cum    Pct.

                                 -------- Westbound only --------
5:01 or more minutes early           0      0.0      0     0.0
4:01 - 5:00 minutes early            0      0.0      0     0.0
3:01 - 4:00 minutes early            0      0.0      0     0.0
2:01 - 3:00 minutes early            0      0.0      0     0.0
1:01 - 2:00 minutes early            0      0.0      0     0.0
0:01 - 1:00 minutes early            0      0.0      0     0.0
On time                              1     11.1      1    11.1
0:01 - 1:00 minutes late             0      0.0      1    11.1
1:01 - 2:00 minutes late             3     33.3      4    44.4
2:01 - 3:00 minutes late             0      0.0      4    44.4
3:01 - 4:00 minutes late             1     11.1      5    55.6
4:01 - 5:00 minutes late             0      0.0      5    55.6
5:01 - 6:00 minutes late             0      0.0      5    55.6
6:01 - 7:00 minutes late             1     11.1      6    66.7
7:01 - 8:00 minutes late             0      0.0      6    66.7
8:01 - 9:00 minutes late             0      0.0      6    66.7
9:01 - 10:00 minutes late            0      0.0      6    66.7
10:01 or more minutes late           3     33.3      9   100.0


Total lateness, all trains           9                 1:29:33
Average lateness, all trains         9                   09:57
Average lateness, late trains        8                   11:12
Latest Train:       925                                  29:13
```

Table 15

```
Lateness Report (Perturbed simulation)
Station: PROVIDENCE
Lateness distribution:              Cnt     Pct.    Cum    Pct.

                                 -------- Westbound only --------
5:01 or more minutes early           0      0.0      0     0.0
4:01 - 5:00 minutes early            0      0.0      0     0.0
3:01 - 4:00 minutes early            0      0.0      0     0.0
2:01 - 3:00 minutes early            0      0.0      0     0.0
1:01 - 2:00 minutes early            0      0.0      0     0.0
0:01 - 1:00 minutes early            0      0.0      0     0.0
On time                              7     28.0      7    28.0
0:01 - 1:00 minutes late             4     16.0     11    44.0
1:01 - 2:00 minutes late             2      8.0     13    52.0
2:01 - 3:00 minutes late             1      4.0     14    56.0
3:01 - 4:00 minutes late             2      8.0     16    64.0
4:01 - 5:00 minutes late             1      4.0     17    68.0
5:01 - 6:00 minutes late             1      4.0     18    72.0
6:01 - 7:00 minutes late             2      8.0     20    80.0
7:01 - 8:00 minutes late             0      0.0     20    80.0
8:01 - 9:00 minutes late             0      0.0     20    80.0
9:01 - 10:00 minutes late            0      0.0     20    80.0
10:01 or more minutes late           5     20.0     25   100.0

Total lateness, all trains          25                 2:03:31
Average lateness, all trains        25                   04:57
Average lateness, late trains       18                   06:52
Latest Train:       819                                  31:03
```

Table 16

```
Lateness Report (Perturbed simulation)
Station: NEEDHAM HEIGHTS
Lateness distribution:            Cnt      Pct.     Cum     Pct.

                               -------- Westbound only --------
5:01 or more minutes early          0     0.0       0     0.0
4:01 - 5:00 minutes early           0     0.0       0     0.0
3:01 - 4:00 minutes early           0     0.0       0     0.0
2:01 - 3:00 minutes early           0     0.0       0     0.0
1:01 - 2:00 minutes early           0     0.0       0     0.0
0:01 - 1:00 minutes early           0     0.0       0     0.0
On time                             0     0.0       0     0.0
0:01 - 1:00 minutes late            1     6.3       1     6.3
1:01 - 2:00 minutes late            6    37.5       7    43.8
2:01 - 3:00 minutes late            3    18.8      10    62.5
3:01 - 4:00 minutes late            2    12.5      12    75.0
4:01 - 5:00 minutes late            2    12.5      14    87.5
5:01 - 6:00 minutes late            0     0.0      14    87.5
6:01 - 7:00 minutes late            0     0.0      14    87.5
7:01 - 8:00 minutes late            0     0.0      14    87.5
8:01 - 9:00 minutes late            0     0.0      14    87.5
9:01 - 10:00 minutes late           0     0.0      14    87.5
10:01 or more minutes late          2    12.5      16   100.0

Total lateness, all trains         16                 1:06:16
Average lateness, all trains       16                   04:09
Average lateness, late trains      16                   04:09
Latest Train:      623                                  23:07
```

Table 17

```
Lateness Report (Perturbed simulation)
Station: FRANKLIN
Lateness distribution:            Cnt      Pct.     Cum     Pct.

                               -------- Westbound only --------
5:01 or more minutes early          0     0.0       0     0.0
4:01 - 5:00 minutes early           0     0.0       0     0.0
3:01 - 4:00 minutes early           0     0.0       0     0.0
2:01 - 3:00 minutes early           0     0.0       0     0.0
1:01 - 2:00 minutes early           0     0.0       0     0.0
0:01 - 1:00 minutes early           0     0.0       0     0.0
On time                             0     0.0       0     0.0
0:01 - 1:00 minutes late            0     0.0       0     0.0
1:01 - 2:00 minutes late            1     6.3       1     6.3
2:01 - 3:00 minutes late            1     6.3       2    12.5
3:01 - 4:00 minutes late            3    18.8       5    31.3
4:01 - 5:00 minutes late            1     6.3       6    37.5
5:01 - 6:00 minutes late            1     6.3       7    43.8
6:01 - 7:00 minutes late            1     6.3       8    50.0
7:01 - 8:00 minutes late            0     0.0       8    50.0
8:01 - 9:00 minutes late            1     6.3       9    56.3
9:01 - 10:00 minutes late           1     6.3      10    62.5
10:01 or more minutes late          6    37.5      16   100.0

Total lateness, all trains         16                 2:39:39
Average lateness, all trains       16                   09:59
Average lateness, late trains      16                   09:59
Latest Train:      721                                  31:00
```

Table 18

```
Lateness Report (Perturbed simulation)
Station: PLYMOUTH
Lateness distribution:              Cnt     Pct.    Cum    Pct.

                                 -------- Westbound only --------
5:01 or more minutes early          0      0.0      0     0.0
4:01 - 5:00 minutes early           0      0.0      0     0.0
3:01 - 4:00 minutes early           0      0.0      0     0.0
2:01 - 3:00 minutes early           0      0.0      0     0.0
1:01 - 2:00 minutes early           0      0.0      0     0.0
0:01 - 1:00 minutes early           0      0.0      0     0.0
On time                             2     50.0      2     0.0
0:01 - 1:00 minutes late            0      0.0      0     0.0
1:01 - 2:00 minutes late            0      0.0      0     0.0
2:01 - 3:00 minutes late            2    100.0      4   100.0
3:01 - 4:00 minutes late            0      0.0      4   100.0
4:01 - 5:00 minutes late            0      0.0      4   100.0
5:01 - 6:00 minutes late            0      0.0      4   100.0
6:01 - 7:00 minutes late            0      0.0      4   100.0
7:01 - 8:00 minutes late            0      0.0      4   100.0
8:01 - 9:00 minutes late            0      0.0      4   100.0
9:01 - 10:00 minutes late           0      0.0      4   100.0
10:01 or more minutes late          0      0.0      4   100.0

Total lateness, all trains          4                     04:33
Average lateness, all trains        4                     02:17
Average lateness, late trains       2                     02:17
Latest Train:      061                                    02:30
```

Table 19

```
Lateness Report (Perturbed simulation)
Station: KINGSTON
Lateness distribution:              Cnt     Pct.    Cum    Pct.

                                 -------- Westbound only --------
5:01 or more minutes early          0      0.0      0     0.0
4:01 - 5:00 minutes early           0      0.0      0     0.0
3:01 - 4:00 minutes early           0      0.0      0     0.0
2:01 - 3:00 minutes early           0      0.0      0     0.0
1:01 - 2:00 minutes early           0      0.0      0     0.0
0:01 - 1:00 minutes early           0      0.0      0     0.0
On time                             0      0.0      0     0.0
0:01 - 1:00 minutes late            0      0.0      0     0.0
1:01 - 2:00 minutes late            0      0.0      0     0.0
2:01 - 3:00 minutes late            0      0.0      0     0.0
3:01 - 4:00 minutes late            2     18.2      2    18.2
4:01 - 5:00 minutes late            1      9.1      3    27.3
5:01 - 6:00 minutes late            1      9.1      4    36.4
6:01 - 7:00 minutes late            3     27.3      7    63.6
7:01 - 8:00 minutes late            1      9.1      8    72.7
8:01 - 9:00 minutes late            1      9.1      9    81.8
9:01 - 10:00 minutes late           0      0.0      9    81.8
10:01 or more minutes late          2     18.2     11   100.0

Total lateness, all trains         11                   1:47:02
Average lateness, all trains       11                     09:44
Average lateness, late trains      11                     09:44
Latest Train:      047                                    36:31
```

Table 20

```
Lateness Report (Perturbed simulation)
Station: MIDDLEBORO/LAKEVILLE
Lateness distribution:              Cnt      Pct.    Cum     Pct.

                                 -------- Westbound only --------
5:01 or more minutes early            0       0.0       0      0.0
4:01 - 5:00 minutes early             0       0.0       0      0.0
3:01 - 4:00 minutes early             0       0.0       0      0.0
2:01 - 3:00 minutes early             0       0.0       0      0.0
1:01 - 2:00 minutes early             0       0.0       0      0.0
0:01 - 1:00 minutes early             0       0.0       0      0.0
On time                               6      50.0       6     50.0
0:01 - 1:00 minutes late              1       8.3       7     58.3
1:01 - 2:00 minutes late              2      16.7       9     75.0
2:01 - 3:00 minutes late              1       8.3      10     83.3
3:01 - 4:00 minutes late              0       0.0      10     83.3
4:01 - 5:00 minutes late              0       0.0      10     83.3
5:01 - 6:00 minutes late              0       0.0      10     83.3
6:01 - 7:00 minutes late              1       8.3      11     91.7
7:01 - 8:00 minutes late              0       0.0      11     91.7
8:01 - 9:00 minutes late              0       0.0      11     91.7
9:01 - 10:00 minutes late             0       0.0      11     91.7
10:01 or more minutes late            1       8.3      12    100.0

Total lateness, all trains           12                      26:39
Average lateness, all trains         12                      02:14
Average lateness, late trains         6                      04:27
Latest Train:       017                                      13:31
```

Table 21

```
Lateness Report (Perturbed simulation)
Station: BACK BAY (B&A Side)
Lateness distribution:              Cnt      Pct.    Cum     Pct.
                                 -------- Westbound only --------
5:01 or more minutes early            0       0.0       0      0.0
4:01 - 5:00 minutes early             0       0.0       0      0.0
3:01 - 4:00 minutes early             0       0.0       0      0.0
2:01 - 3:00 minutes early             0       0.0       0      0.0
1:01 - 2:00 minutes early             0       0.0       0      0.0
0:01 - 1:00 minutes early             0       0.0       0      0.0
On time                              11      50.0      11     50.0
0:01 - 1:00 minutes late              4      18.2      15     68.2
1:01 - 2:00 minutes late              3      13.6      18     81.8
2:01 - 3:00 minutes late              0       0.0      18     81.8
3:01 - 4:00 minutes late              1       4.5      19     86.4
4:01 - 5:00 minutes late              0       0.0      19     86.4
5:01 - 6:00 minutes late              1       4.5      20     90.9
6:01 - 7:00 minutes late              0       0.0      20     90.9
7:01 - 8:00 minutes late              0       0.0      20     90.9
8:01 - 9:00 minutes late              0       0.0      20     90.9
9:01 - 10:00 minutes late             0       0.0      20     90.9
10:01 or more minutes late            2       9.1      22    100.0

Total lateness, all trains           22                      41:42
Average lateness, all trains         22                      01:54
Average lateness, late trains        11                      03:48
Latest Train:       575                                      14:00
```

The final lateness distribution in this series of perturbed simulation results is for arriving revenue trains at South Station during the 24-hour period (non-revenue trains are excluded). Comparing this distribution with the South Station lateness report for the deterministic model, there has been a marked shift in train lateness. In the deterministic model (unperturbed), 91 revenue trains arrived at South Station early, on time or within one minute of schedule. "Only" 10 trains were more than 4 minutes late. The latest train was 6:15 late. In the perturbed model, only 18 trains arrived South Station early, on-time or within one minute of schedule. Seventy-nine trains were more than 4 minutes late; of those, 35 trains were more than ten minutes late. The latest train was #774, 32:40 late. Accordingly, the *average* lateness of late trains increased from just 1:55 to 7:11.

Table 22

```
Lateness Report  (Perturbed simulation)
Station: SOUTH STATION
Lateness distribution:              Cnt      Pct.    Cum     Pct.
                                 -------- Eastbound only --------
5:01 or more minutes early            0      0.0       0     0.0
4:01 - 5:00 minutes early             0      0.0       0     0.0
3:01 - 4:00 minutes early             0      0.0       0     0.0
2:01 - 3:00 minutes early             0      0.0       0     0.0
1:01 - 2:00 minutes early             3      2.0       3     2.0
0:01 - 1:00 minutes early             6      4.1       9     6.1
On time                               0      0.0       9     6.1
0:01 - 1:00 minutes late              9      6.1      18    12.2
1:01 - 2:00 minutes late             22     15.0      40    27.2
2:01 - 3:00 minutes late             13      8.8      53    36.1
3:01 - 4:00 minutes late             15     10.2      68    46.3
4:01 - 5:00 minutes late              9      6.1      77    52.4
5:01 - 6:00 minutes late             13      8.8      90    61.2
6:01 - 7:00 minutes late              8      5.4      98    66.7
7:01 - 8:00 minutes late              8      5.4     106    72.1
8:01 - 9:00 minutes late              5      3.4     111    75.5
9:01 - 10:00 minutes late             1      0.7     112    76.2
10:01 or more minutes late           35     23.8     147   100.0

Total lateness, all trains          147                 16:21:33
Average lateness, all trains        147                    06:41
Average lateness, late trains       138                    07:11
Latest Train:       774                                    32:40
```

The results of the perturbed simulation indicate that the network is stressed even by modest fluctuations in terminal start times and intermediate station dwell times. Three elements played a role in the degraded results:

- Lack of MBTA ability to interpret 9-Aspect ATC system on the Northeast Corridor, resulting in MBTA trains delaying Amtrak trains when MBTA *or* Amtrak trains – or both – operated out-of-slot.
- Inadequate overtake facilities on Northeast Corridor. The only feasible overtake point where Amtrak trains can move ahead of MBTA trains operating in the same direction is at Attleboro. The three-track segment between Readville (Transfer Interlocking) and Back Bay cannot support overtakes during peak period operations because of traffic density.
- Dispatcher judgment. The simulation cannot completely mimic the judgment and experience of a seasoned Train Dispatcher who can – and will – make decisions to manage late trains. For example, a Dispatcher may elect to advance a late train ahead of other traffic to help it recover schedule. However, on some properties a very late train is managed by the Train Dispatcher to isolate the late train to prevent or minimize cascading delays to other trains that

are operating closer to schedule. This technique or policy implies that at some point, a very late train is considered "hopeless" and the dispatching strategy becomes one of containment.

An additional, "severe disruption" scenario was simulated in which some trains (selected at random by the simulator) departed outlying terminal stations extremely late (up to approximately 25 minutes late). This disruption scenario was undertaken to see what happens to the operation of the railroad under conditions resembling a snowstorm, when multiple delays occur due to poor visibility, frozen switchpoints, maintainers shoveling turnouts and collateral station dwell delays. The lateness reports presented below identify the fact that some trains were egregiously late due to cascading delays. For example, Train 907 arrived at Fall River more than 37 minutes late. This delay, like most others, was *not* due to conflicts south of ("west" of) Canton Junction -- where the proposed infrastructure handled traffic well even under disrupted conditions. Rather, the lateness was due to delays on the Northeast Corridor and at South Station.

Table 23

```
Lateness Report (Severe disruption)
Station: FALL RIVER
Lateness distribution:              Cnt      Pct.     Cum     Pct.

                                 -------- Westbound only --------
5:01 or more minutes early           0      0.0        0      0.0
4:01 - 5:00 minutes early            0      0.0        0      0.0
3:01 - 4:00 minutes early            0      0.0        0      0.0
2:01 - 3:00 minutes early            0      0.0        0      0.0
1:01 - 2:00 minutes early            0      0.0        0      0.0
0:01 - 1:00 minutes early            0      0.0        0      0.0
On time                              0      0.0        0      0.0
0:01 - 1:00 minutes late             0      0.0        0      0.0
1:01 - 2:00 minutes late             1     10.0        1     10.0
2:01 - 3:00 minutes late             2     20.0        3     30.0
3:01 - 4:00 minutes late             0      0.0        3     30.0
4:01 - 5:00 minutes late             0      0.0        3     30.0
5:01 - 6:00 minutes late             1     10.0        4     40.0
6:01 - 7:00 minutes late             0      0.0        4     40.0
7:01 - 8:00 minutes late             1     10.0        5     50.0
8:01 - 9:00 minutes late             0      0.0        5     50.0
9:01 - 10:00 minutes late            0      0.0        5     50.0
10:01 or more minutes late           5     50.0       10    100.0

Total lateness, all trains          10                   2:12:48
Average lateness, all trains        10                     13:17
Average lateness, late trains       10                     13:17
Latest Train:      907                                     37:13
```

Table 24

```
Lateness Report  (Severe disruption)
Station: NEW BEDFORD
Lateness distribution:            Cnt     Pct.    Cum    Pct.

                               -------- Westbound only --------
5:01 or more minutes early          0      0.0      0     0.0
4:01 - 5:00 minutes early           0      0.0      0     0.0
3:01 - 4:00 minutes early           0      0.0      0     0.0
2:01 - 3:00 minutes early           0      0.0      0     0.0
1:01 - 2:00 minutes early           0      0.0      0     0.0
0:01 - 1:00 minutes early           0      0.0      0     0.0
On time                             0      0.0      0     0.0
0:01 - 1:00 minutes late            1     10.0      1    10.0
1:01 - 2:00 minutes late            1     10.0      2    20.0
2:01 - 3:00 minutes late            1     10.0      3    30.0
3:01 - 4:00 minutes late            0      0.0      3    30.0
4:01 - 5:00 minutes late            0      0.0      3    30.0
5:01 - 6:00 minutes late            0      0.0      3    30.0
6:01 - 7:00 minutes late            1     10.0      4    40.0
7:01 - 8:00 minutes late            1     10.0      5    50.0
8:01 - 9:00 minutes late            0      0.0      5    50.0
9:01 - 10:00 minutes late           0      0.0      5    50.0
10:01 or more minutes late          5     50.0     10   100.0

Total lateness, all trains         10                 2:01:16
Average lateness, all trains       10                   12:08
Average lateness, late trains      10                   12:08
Latest Train:       909                                 30:40
```

Table 25

```
Lateness Report  (Severe disruption)
Station: PROVIDENCE
Lateness distribution:            Cnt     Pct.    Cum    Pct.

                               -------- Westbound only --------
5:01 or more minutes early          0      0.0      0     0.0
4:01 - 5:00 minutes early           0      0.0      0     0.0
3:01 - 4:00 minutes early           0      0.0      0     0.0
2:01 - 3:00 minutes early           0      0.0      0     0.0
1:01 - 2:00 minutes early           0      0.0      0     0.0
0:01 - 1:00 minutes early           0      0.0      0     0.0
On time                             8     32.0      8    32.0
0:01 - 1:00 minutes late            2      8.0     10    40.0
1:01 - 2:00 minutes late            0      0.0     10    40.0
2:01 - 3:00 minutes late            2      8.0     12    48.0
3:01 - 4:00 minutes late            2      8.0     14    56.0
4:01 - 5:00 minutes late            0      0.0     14    56.0
5:01 - 6:00 minutes late            1      4.0     15    60.0
6:01 - 7:00 minutes late            1      4.0     16    64.0
7:01 - 8:00 minutes late            0      0.0     16    64.0
8:01 - 9:00 minutes late            0      0.0     16    64.0
9:01 - 10:00 minutes late           1      4.0     17    68.0
10:01 or more minutes late          8     32.0     25   100.0

Total lateness, all trains         25                 3:06:28
Average lateness, all trains       25                   07:28
Average lateness, late trains      17                   10:59
Latest Train:       817                                 28:00
```

Table 26

```
Lateness Report (Severe disruption)
Station: NEEDHAM HEIGHTS
Lateness distribution:              Cnt      Pct.     Cum     Pct.

                                 -------- Westbound only --------
5:01 or more minutes early            0      0.0        0     0.0
4:01 - 5:00 minutes early             0      0.0        0     0.0
3:01 - 4:00 minutes early             0      0.0        0     0.0
2:01 - 3:00 minutes early             0      0.0        0     0.0
1:01 - 2:00 minutes early             0      0.0        0     0.0
0:01 - 1:00 minutes early             0      0.0        0     0.0
On time                               0      0.0        0     0.0
0:01 - 1:00 minutes late              0      0.0        0     0.0
1:01 - 2:00 minutes late              1      6.3        1     6.3
2:01 - 3:00 minutes late              3     18.8        4    25.0
3:01 - 4:00 minutes late              0      0.0        4    25.0
4:01 - 5:00 minutes late              0      0.0        4    25.0
5:01 - 6:00 minutes late              0      0.0        4    25.0
6:01 - 7:00 minutes late              0      0.0        4    25.0
7:01 - 8:00 minutes late              0      0.0        4    25.0
8:01 - 9:00 minutes late              1      6.3        5    31.3
9:01 - 10:00 minutes late             1      6.3        6    37.5
10:01 or more minutes late           10     62.5       16   100.0

Total lateness, all trains           16               4:55:13
Average lateness, all trains         16                 18:28
Average lateness, late trains        16                 18:28
Latest Train:       625                               1:16:34
```

Table 27

```
Lateness Report (Severe disruption)
Station: FRANKLIN
Lateness distribution:              Cnt      Pct.     Cum     Pct.

                                 -------- Westbound only --------
5:01 or more minutes early            0      0.0        0     0.0
4:01 - 5:00 minutes early             0      0.0        0     0.0
3:01 - 4:00 minutes early             0      0.0        0     0.0
2:01 - 3:00 minutes early             0      0.0        0     0.0
1:01 - 2:00 minutes early             0      0.0        0     0.0
0:01 - 1:00 minutes early             0      0.0        0     0.0
On time                               0      0.0        0     0.0
0:01 - 1:00 minutes late              1      6.3        1     6.3
1:01 - 2:00 minutes late              0      0.0        1     6.3
2:01 - 3:00 minutes late              0      0.0        1     6.3
3:01 - 4:00 minutes late              1      6.3        2    12.5
4:01 - 5:00 minutes late              1      6.3        3    18.8
5:01 - 6:00 minutes late              0      0.0        3    18.8
6:01 - 7:00 minutes late              1      6.3        4    25.0
7:01 - 8:00 minutes late              1      6.3        5    31.3
8:01 - 9:00 minutes late              0      0.0        5    31.3
9:01 - 10:00 minutes late             1      6.3        6    37.5
10:01 or more minutes late           10     62.5       16   100.0

Total lateness, all trains           16               5:13:36
Average lateness, all trains         16                 19:36
Average lateness, late trains        16                 19:36
Latest Train:       721                                 46:24
```

Table 28

```
Lateness Report (Severe disruption)
Station: PLYMOUTH
Lateness distribution:             Cnt     Pct.    Cum    Pct.

                                -------- Westbound only --------
5:01 or more minutes early           0      0.0      0     0.0
4:01 - 5:00 minutes early            0      0.0      0     0.0
3:01 - 4:00 minutes early            0      0.0      0     0.0
2:01 - 3:00 minutes early            0      0.0      0     0.0
1:01 - 2:00 minutes early            0      0.0      0     0.0
0:01 - 1:00 minutes early            0      0.0      0     0.0
On time                              2     50.0      2    50.0
0:01 - 1:00 minutes late             0      0.0      0     0.0
1:01 - 2:00 minutes late             0      0.0      0     0.0
2:01 - 3:00 minutes late             1     25.0      3    75.0
3:01 - 4:00 minutes late             0      0.0      3    75.0
4:01 - 5:00 minutes late             0      0.0      3    75.0
5:01 - 6:00 minutes late             0      0.0      3    75.0
6:01 - 7:00 minutes late             0      0.0      3    75.0
7:01 - 8:00 minutes late             0      0.0      3    75.0
8:01 - 9:00 minutes late             0      0.0      3    75.0
9:01 - 10:00 minutes late            0      0.0      3    75.0
10:01 or more minutes late           1     25.0      4   100.0

Total lateness, all trains           4                   27:04
Average lateness, all trains         4                   06:46
Average lateness, late trains        2                   13:33
Latest Train:       061                                  24:58
```

Table 29

```
Lateness Report (Severe disruption)
Station: KINGSTON
Lateness distribution:             Cnt     Pct.    Cum    Pct.

                                -------- Westbound only --------

5:01 or more minutes early           0      0.0      0     0.0
4:01 - 5:00 minutes early            0      0.0      0     0.0
3:01 - 4:00 minutes early            0      0.0      0     0.0
2:01 - 3:00 minutes early            0      0.0      0     0.0
1:01 - 2:00 minutes early            0      0.0      0     0.0
0:01 - 1:00 minutes early            0      0.0      0     0.0
On time                              0      0.0      0     0.0
0:01 - 1:00 minutes late             0      0.0      0     0.0
1:01 - 2:00 minutes late             2     18.2      2    18.2
2:01 - 3:00 minutes late             1      9.1      3    27.2
3:01 - 4:00 minutes late             1      9.1      4    36.4
4:01 - 5:00 minutes late             2     18.2      6    54.5
5:01 - 6:00 minutes late             2     18.2      8    72.7
6:01 - 7:00 minutes late             0      0.0      8    72.7
7:01 - 8:00 minutes late             1      9.1      9    81.8
8:01 - 9:00 minutes late             0      0.0      9    81.8
9:01 - 10:00 minutes late            1      9.1     10    90.9
10:01 or more minutes late           1      9.1     11   100.0

Total lateness, all trains          11                 1:05:25
Average lateness, all trains        11                   05:02
Average lateness, late trains       11                   05:02
Latest Train:       049                                  18:16
```

Table 30

```
Lateness Report (Severe disruption)
Station: MIDDLEBORO/LAKEVILLE
Lateness distribution:          Cnt     Pct.    Cum    Pct.

                             -------- Westbound only --------
5:01 or more minutes early        0     0.0       0     0.0
4:01 - 5:00 minutes early         0     0.0       0     0.0
3:01 - 4:00 minutes early         0     0.0       0     0.0
2:01 - 3:00 minutes early         0     0.0       0     0.0
1:01 - 2:00 minutes early         0     0.0       0     0.0
0:01 - 1:00 minutes early         0     0.0       0     0.0
On time                           7    58.3       7    58.3
0:01 - 1:00 minutes late          2    16.7       9    75.0
1:01 - 2:00 minutes late          1     8.3      10    83.3
2:01 - 3:00 minutes late          0     0.0      10    83.3
3:01 - 4:00 minutes late          1     8.3      11    91.7
4:01 - 5:00 minutes late          0     0.0      11    91.7
5:01 - 6:00 minutes late          0     0.0      11    91.7
6:01 - 7:00 minutes late          0     0.0      11    91.7
7:01 - 8:00 minutes late          0     0.0      11    91.7
8:01 - 9:00 minutes late          0     0.0      11    91.7
9:01 - 10:00 minutes late         0     0.0      11    91.7
10:01 or more minutes late        1     8.3      12   100.0

Total lateness, all trains       12                   24:45
Average lateness, all trains     12                   02:04
Average lateness, late trains     5                   04:57
Latest Train:       005                               17:48
```

Table 31

```
Lateness Report (Severe disruption)
Station: BACK BAY (B&A Side)
Lateness distribution:          Cnt     Pct.    Cum    Pct.
                             -------- Westbound only --------
5:01 or more minutes early        0     0.0       0     0.0
4:01 - 5:00 minutes early         0     0.0       0     0.0
3:01 - 4:00 minutes early         0     0.0       0     0.0
2:01 - 3:00 minutes early         0     0.0       0     0.0
1:01 - 2:00 minutes early         0     0.0       0     0.0
0:01 - 1:00 minutes early         0     0.0       0     0.0
On time                           7    31.8       7    31.8
0:01 - 1:00 minutes late          2     9.1       9    40.9
1:01 - 2:00 minutes late          2     9.1      11    50.0
2:01 - 3:00 minutes late          1     4.5      12    54.5
3:01 - 4:00 minutes late          0     0.0      12    54.5
4:01 - 5:00 minutes late          1     4.5      13    59.1
5:01 - 6:00 minutes late          0     0.0      13    59.1
6:01 - 7:00 minutes late          1     4.5      14    63.6
7:01 - 8:00 minutes late          1     4.5      15    68.2
8:01 - 9:00 minutes late          0     0.0      15    68.2
9:01 - 10:00 minutes late         1     4.5      16    72.7
10:01 or more minutes late        6    27.3      22   100.0
Total lateness, all trains       22                 3:42:24
Average lateness, all trains     22                   10:07
Average lateness, late trains    15                   14:50
Latest Train:       571                             1:03:31
```

The final table, below, displays on-time performance under perturbed conditions for all trains arriving at South Station in simulation – Amtrak and MBTA. Note that the average lateness of 138 late trains was 15 minutes 37 seconds, which is extremely poor. New Bedford Train 9906, which is supposed to arrive South Station at 8:08 AM, was more than one hour late. This was caused by the train leaving New Bedford very late, arriving at South Station late and finding its assigned track already occupied. A Train Dispatcher would have attempted to take steps to route this very late train into another track at South Station as soon as a track was available in order to avoid further delay at Cove Interlocking/Tower 1 and cascading delays to following traffic.

Table 32

```
Lateness Report (Severe disruption)
Station: SOUTH STATION
Lateness distribution:            Cnt     Pct.    Cum    Pct.
                                 -------- Eastbound only --------
5:01 or more minutes early          0      0.0      0     0.0
4:01 - 5:00 minutes early           0      0.0      0     0.0
3:01 - 4:00 minutes early           0      0.0      0     0.0
2:01 - 3:00 minutes early           1      0.7      1     0.7
1:01 - 2:00 minutes early           4      2.7      5     3.4
0:01 - 1:00 minutes early           3      2.1      8     5.5
On time                             0      0.0      8     5.5
0:01 - 1:00 minutes late            4      2.7     12     8.2
1:01 - 2:00 minutes late            9      6.2     21    14.4
2:01 - 3:00 minutes late            7      4.8     28    19.2
3:01 - 4:00 minutes late            8      5.5     36    24.7
4:01 - 5:00 minutes late           10      6.8     46    31.5
5:01 - 6:00 minutes late            2      1.4     48    32.9
6:01 - 7:00 minutes late            5      3.4     53    36.3
7:01 - 8:00 minutes late            7      4.8     60    41.1
8:01 - 9:00 minutes late            2      1.4     62    42.5
9:01 - 10:00 minutes late           6      4.1     68    46.6
10:01 or more minutes late         78     53.4    146   100.0
Total lateness, all trains        146              35:43:48
Average lateness, all trains      146                 14:42
Average lateness, late trains     138                 15:37
Latest Train:      9906                             1:02:06
```

SIGNAL DELAY

Signal Delay is the time during which trains are forced to operate under signal indications that are less favorable than the best possible indication. Signal Delay measures traffic congestion independently of scheduled arrival and departure times. Signal Delay time is not lateness. For example, if a train operates at 30 miles-per-hour for 90 seconds because of an Approach indication, 90 seconds of Signal Delay is experienced, but this is not the same thing as saying that the train is 90 seconds "late". In fact, the train might still be "on time" depending on the amount of recovery time built into its schedule.

Signal delay minutes were computed and totaled for Signal Delays accruing on the Northeast Corridor to the Amtrak and MBTA revenue trains in simulation. Signal delays *caused by* non-revenue trains were included in the totals, but signal delays *encountered by* non-revenue trains were not. This is because non-revenue trains are almost always inferior to revenue trains and may be intentionally held back by a Train Dispatcher at his or her discretion to protect the schedule of a revenue train. Moreover, signal delays occurring on the Old Colony Lines (Middleboro and Plymouth/Kingston) were not included except for delays that occurred within the South Station terminal area. Signal delays occurring at outlying points on the Old Colony Lines are irrelevant to the analysis and would only serve to obscure the findings.

The peak periods of 6:00 to 9:00 AM and 4:00 to 7:00 PM were broken out, because average train delay over a full 24-hour period that includes the late-night hours when few trains operate is not particularly meaningful. Signal delay results were generated for "ideal" and for "perturbed" operations. Under "ideal" simulation, all equipment initially enters service "on time" and station and terminal dwell times are fixed. Under "perturbed" simulation, terminal departure and intermediate station dwells are statistically randomized to reflect real-world variations in day-to-day operations. For example, an MBTA or Amtrak train could experience an unpredictable delay leaving Providence Station for any number of reasons ranging from a minor mechanical problem to unusual travel demand or a passenger requiring assistance. The "perturbed" simulation stresses the system and its response to this "stress" is measured quantitatively.

The following three tables display and compare system "signal delay" under a deterministic ("ideal") and two randomized ("perturbed") simulations. The signal delay totals indicate three important findings:

- When operations are normal (i.e., "on time"), signal delay totals are modest and the operation runs smoothly. For example, signal delay incurred by Amtrak revenue trains is vanishingly small when distributed among the 38 revenue Amtrak trains in simulation -- some 2 minutes 33 seconds per train! This includes the entire simulated territory from Providence to and including South Station, plus the Worcester Line east of Beacon Park.

- When operations are moderately disrupted, the network is able to recover from cumulative morning peak-period delays during the mid-day period and the evening peak begins with reasonably fluid operations. Signal delay accruing to revenue trains on the Northeast Corridor between Providence and South Station somewhat more than doubles, and this is not a surprising result given intense traffic volume, close headways and the dissimilar operating performance capabilities of the three distinct types of trains that will be operated. It was observed during simulations that even moderate delays (under 10 minutes) can cause Amtrak or MBTA trains to fall out-of-slot on the Northeast Corridor. This often resulted in multiple prolonged signal delays to a following Amtrak High Speed or even Amtrak "Conventional" trains. To solve this problem, more overtake capability is needed on the Corridor between Attleboro and Readville, which is beyond the Scope of this report.

When operations are *severely* disrupted, signal delays multiply substantially, indicating an unstable operation. Accrued Amtrak signal delay nearly quadruples (238% increase) over the 24-hour period. Amtrak delays occur because of delays between Cove Interlocking and South Station and when Amtrak trains become delayed behind slower MBTA trains on the Northeast Corridor. Given its limited infrastructure lacking dedicated "express" and "local" tracks (that it once had), the Northeast Corridor/Providence Line does not operate well when High Speed and Commuter trains are commingled and trains operate severely "out of slot" under disrupted conditions. Amtrak's actual signal delay experience under simulated severely disrupted conditions was actually better than expected. The 238% increase to 5 hours 26-3/4 minutes is from the small base noted above; each revenue Amtrak train in simulation incurred less than 9 minutes of signal delay, *on average*, even under perturbed conditions. *Again, this does not necessarily mean these trains were stopped.*

Table 33 **Northeast Corridor, South Station, & New Bedford / Fall River**

Summary of Signal Delay (h:mm:ss)

"Ideal" Operations (including Fall River and New Bedford trains)

	MBTA Revenue Trains	Amtrak Revenue Trains
AM Peak (6-9 AM)	1:16:53	0:14:40
PM Peak (4-7 PM)	2:28:59	0:25:38
24 Hours	5:32:44	1:36:41

Table 34 **Northeast Corridor, South Station, & New Bedford / Fall River**

Summary of Signal Delay (h:mm:ss)

"Perturbed" Model (including Fall River and New Bedford trains)

	MBTA RevenueTrains		Amtrak Revenue Trains	
	Time	% Change	Time	% Change
AM Peak (6-9 AM)	3:15:32	154.3%	0:24:30	67.0%
PM Peak (4-7 PM)	3:59:15	60.6%	0:49:26	92.8%
24 Hours	11:09:46	101.3%	3:38:50	126.3%

Table 35 **Northeast Corridor, South Station, & New Bedford / Fall River**

Summary of Signal Delay (h:mm:ss)

"Severe Perturbed" operations (incl. Fall River and New Bedford trains)

	MBTA RevenueTrains		Amtrak RevenueTrains	
	Time	% Change	Time	% Change
AM Peak (6-9 AM)	5:48:18	353.0%	0:56:34	285.7%
PM Peak (4-7 PM)	4:51:38	95.7%	1:46:13	314.4%
24 Hours	17:25:16	214.1%	5:26:45	238.0%

Includes all signal delay incurred on or related to:

Northeast Corridor (between west limits of Cove and Providence).

South Station terminal area (Cove and Tower 1).

NB/FR branches (between west limits of Canton Junction. & New Bedford / Fall River).

Percent change is from "deterministic" model.

STRING CHARTS

The following five String Charts (train diagrams) display the simulated train operations from Fall River and New Bedford to South Station via Canton Junction. Each String Chart covers a four-hour period: 6 AM to 10 AM, 10 AM to 2 PM, 2 PM to 6 PM, 6 PM to 10 PM and 10 PM to 2 AM. The first departure from New Bedford is programmed to leave at 5:45 PM and appears on the first string chart of the series at East Taunton, where it stops at 6:04 AM.

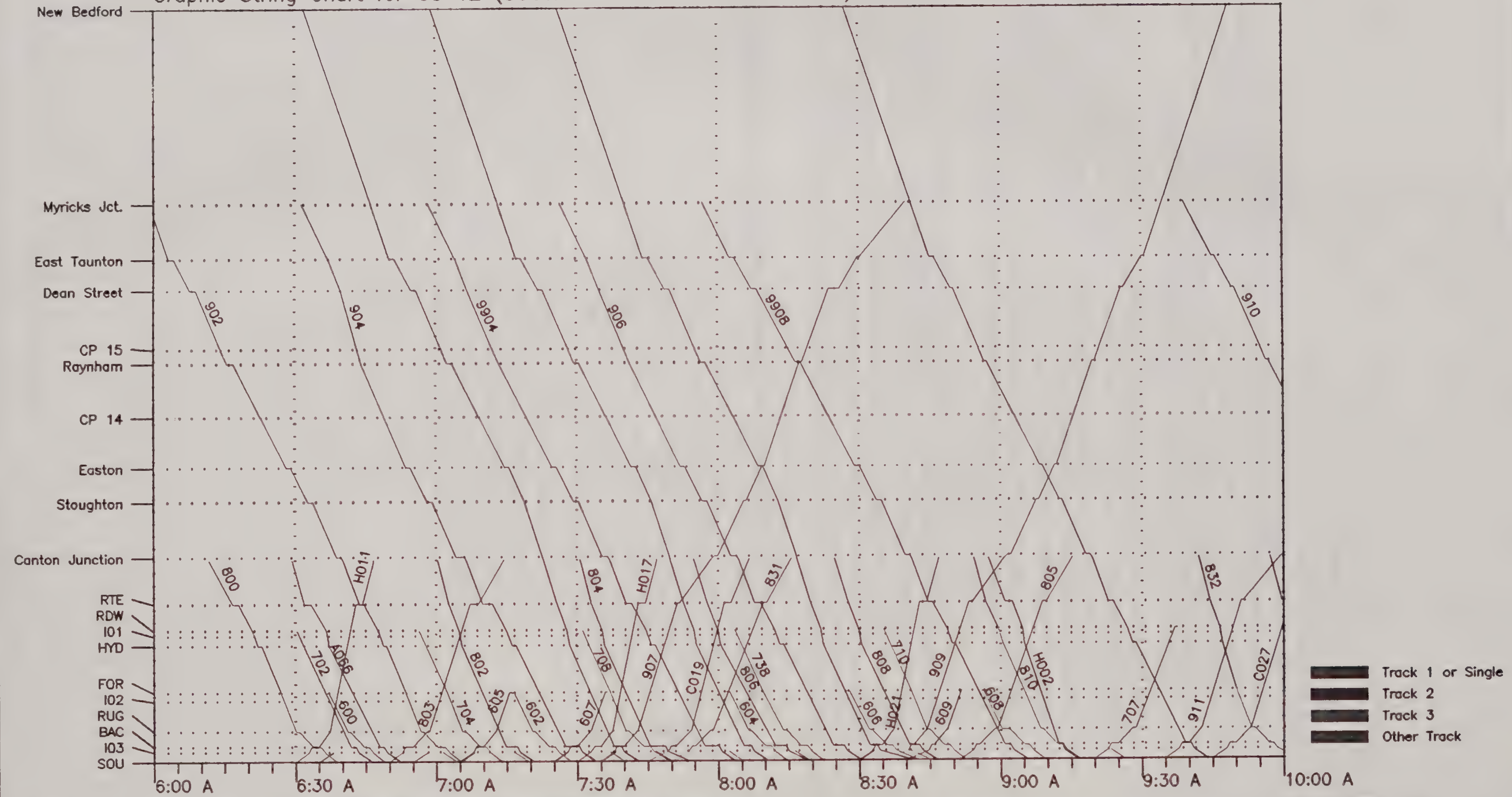
The string lines demonstrate how the proposed New Bedford and Fall River trains are "dovetailed" into Northeast Corridor operations at Canton Junction. Of interest also is that the Operating Plan deliberately causes as many "meets" with opposing New Bedford and Fall River trains south of Canton Junction to take place on double-tracked segments. The double-tracked segment (proposed) between Canton Junction and Easton is used extensively to meet and pass trains moving in opposite directions without delaying either train. Similarly, the segment between Hart Street in Taunton and Myricks Junction is also used extensively for this purpose.

Meets involving short sidings such as at Freetown, Thrasher-Winter Streets and Raynham were minimized. An exception is Train 928. This train departs Fall River at 6:12 PM and encounters several peak-direction trains on its way back to South Station. It is scheduled to meet Train #889 at Freetown, meet #919 near East Taunton, then meet #921 at Thrasher Street (or alternatively at Raynham if #921 is late) and finally meet Train #923 on the double-tracked segment north (railroad "east") of Easton. (See the fourth String Chart, depicting operations from 6:00 PM to 10:00 PM.)

The excessive number of meets encountered by this reverse-peak train (#928) resulted in the need to add fifteen minutes to its schedule.

MBTA Fall River/New Bedford Simulation

Graphic String Chart for GS 12 (SOUTH STATION – NEW BEDFORD)



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New Bedford / Fall River Commuter Rail

OPERATIONS SIMULATION REPORT

Figure 2

New Bedford to South Station String Chart

6:00AM TO 10:00AM

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Sheet 1 of 5	
SCALE	NTS
DATE	Jan. 18, 1999
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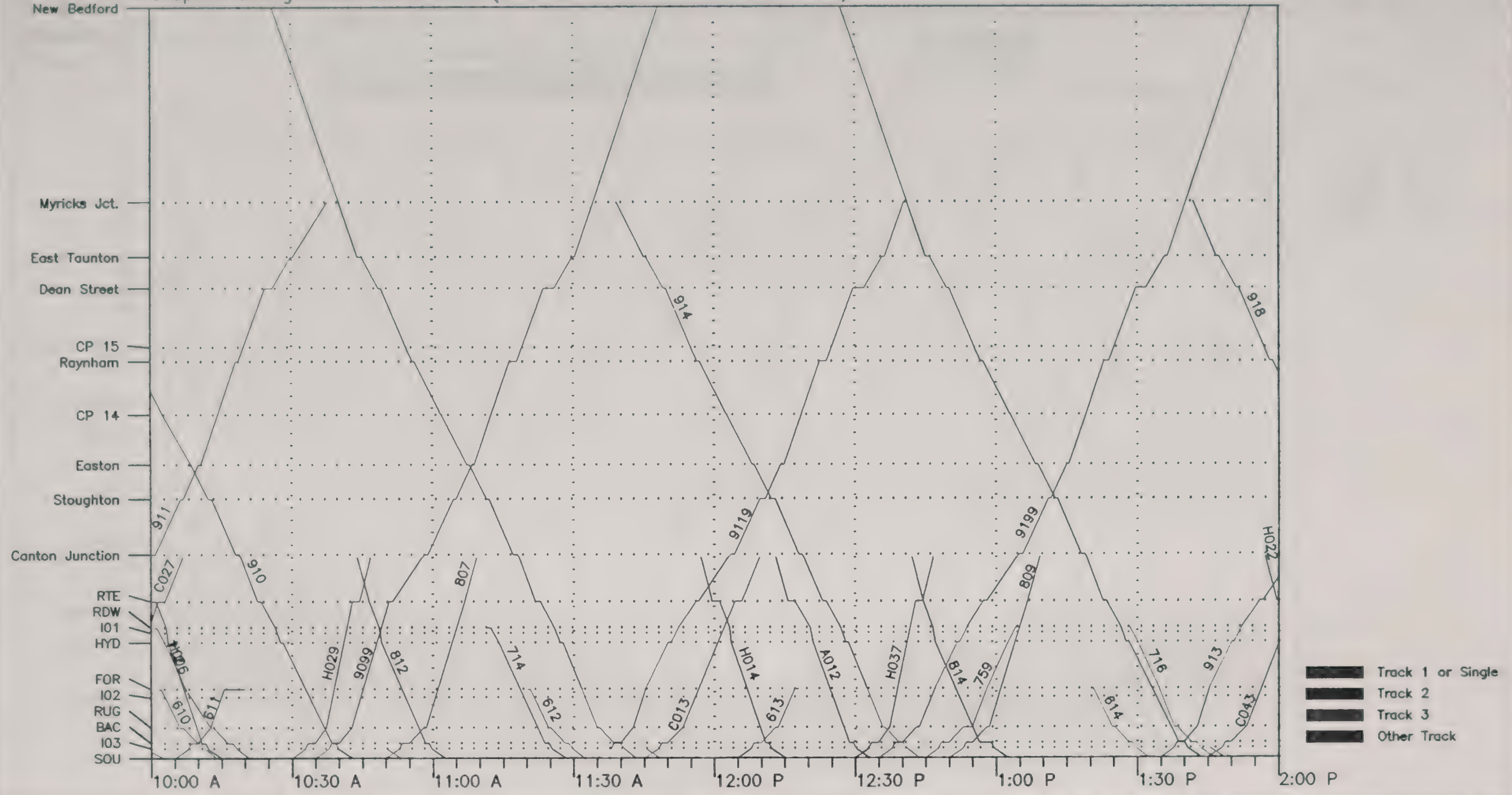
CHECKED BY	GN

MBTA Fall River/New Bedford Simulation

Graphic String Chart for GS 12 (SOUTH STATION – NEW BEDFORD)



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OPERATIONS SIMULATION REPORT

Figure 3

New Bedford to South Station String Chart

10:00AM TO 2:00PM

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Sheet 2 of 5

SCALE NTS

DATE Jan. 18, 1999

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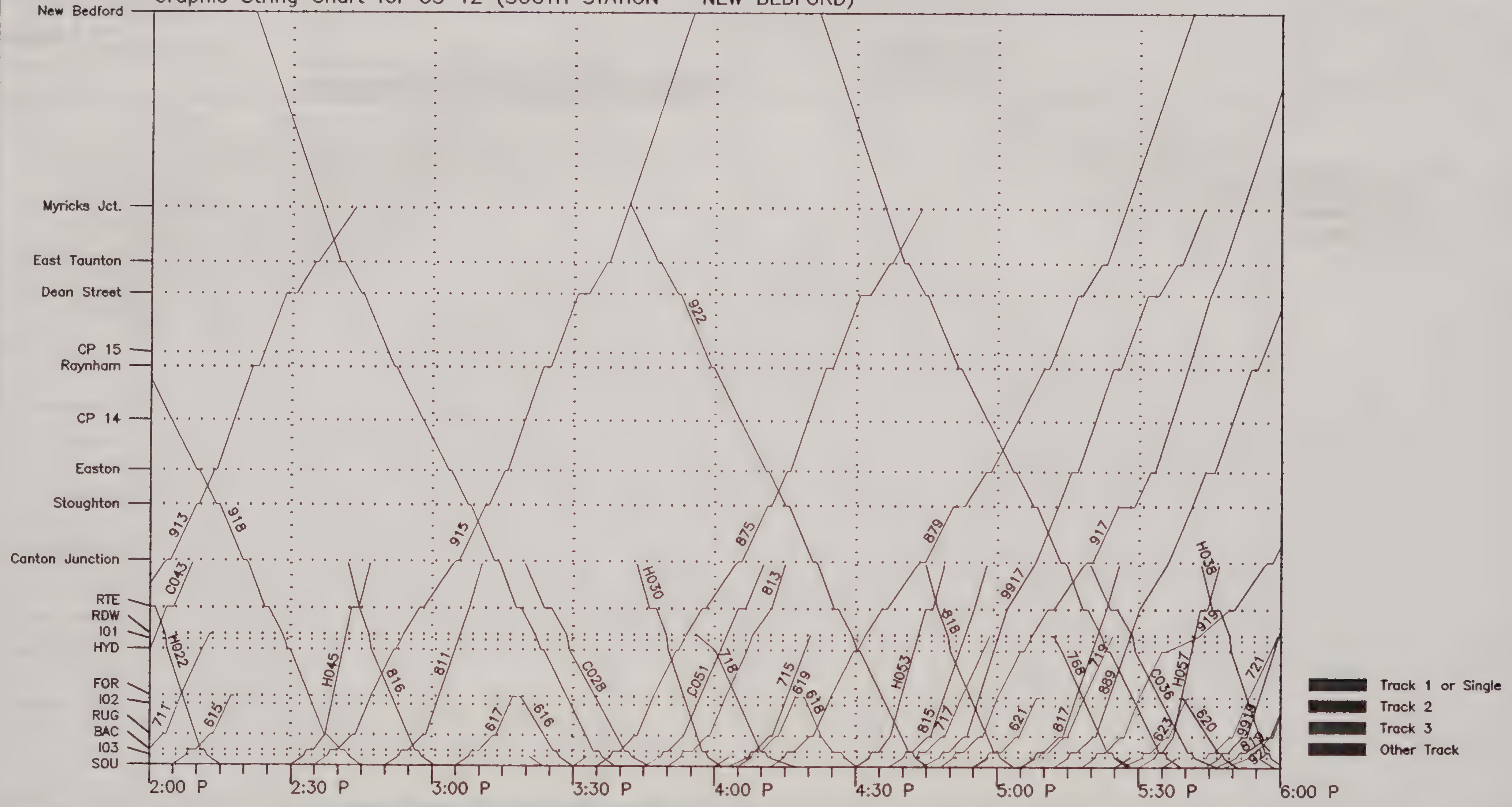
MBTA Fall River/New Bedford Simulation

Graphic String Chart for GS 12 (SOUTH STATION – NEW BEDFORD)



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New Bedford / Fall River Commuter Rail

OPERATIONS SIMULATION REPORT

Figure 4

New Bedford to South Station String Chart

2:00PM TO 6:00PM

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Sheet 3 of 5

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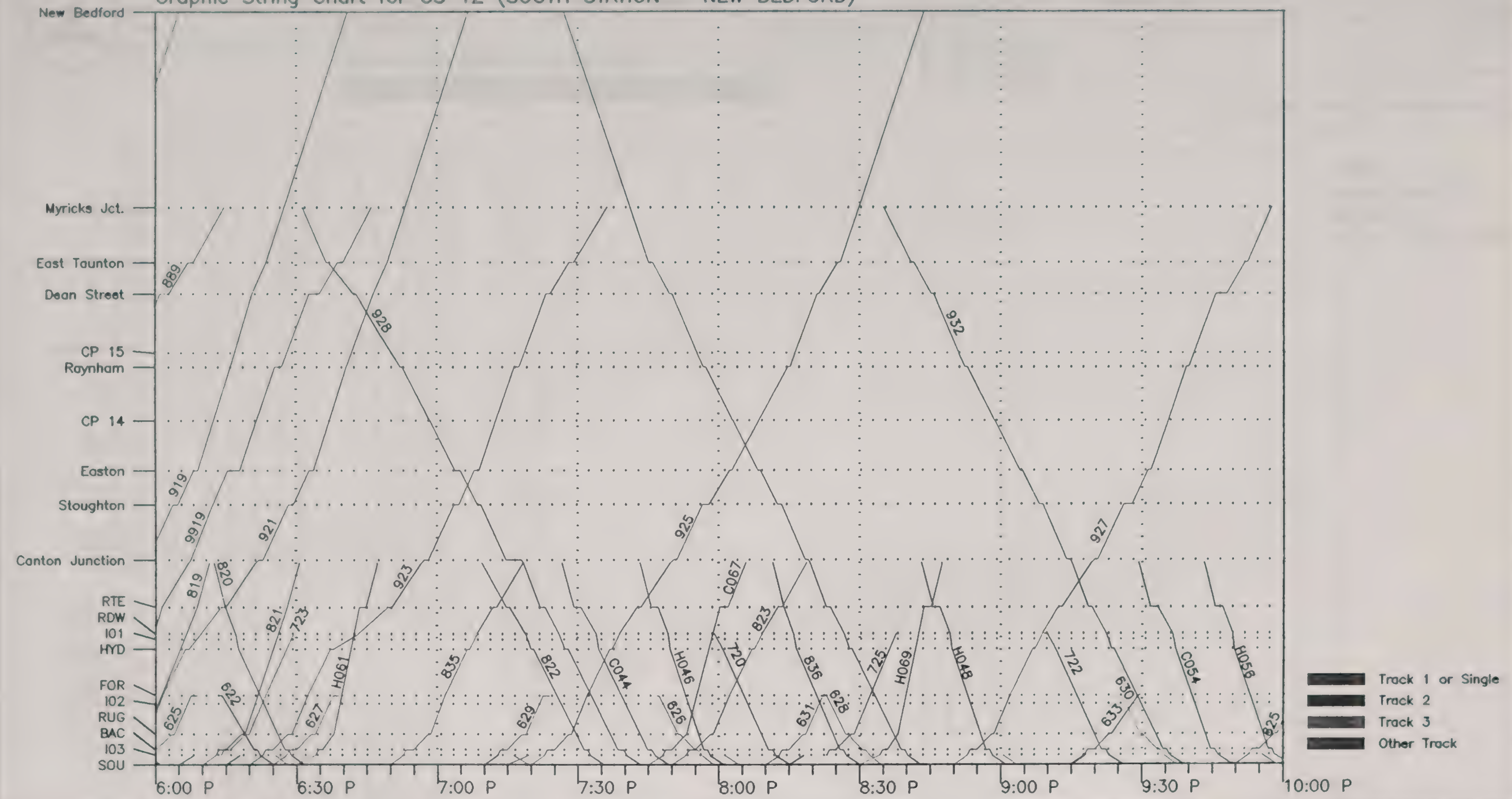
MBTA Fall River/New Bedford Simulation

Graphic String Chart for GS 12 (SOUTH STATION – NEW BEDFORD)



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New Bedford / Fall River Commuter Rail

OPERATIONS SIMULATION REPORT

Figure 5

New Bedford to South Station String Chart

6:00PM TO 10:00PM

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Sheet 4 of 5

SCALE	NTS
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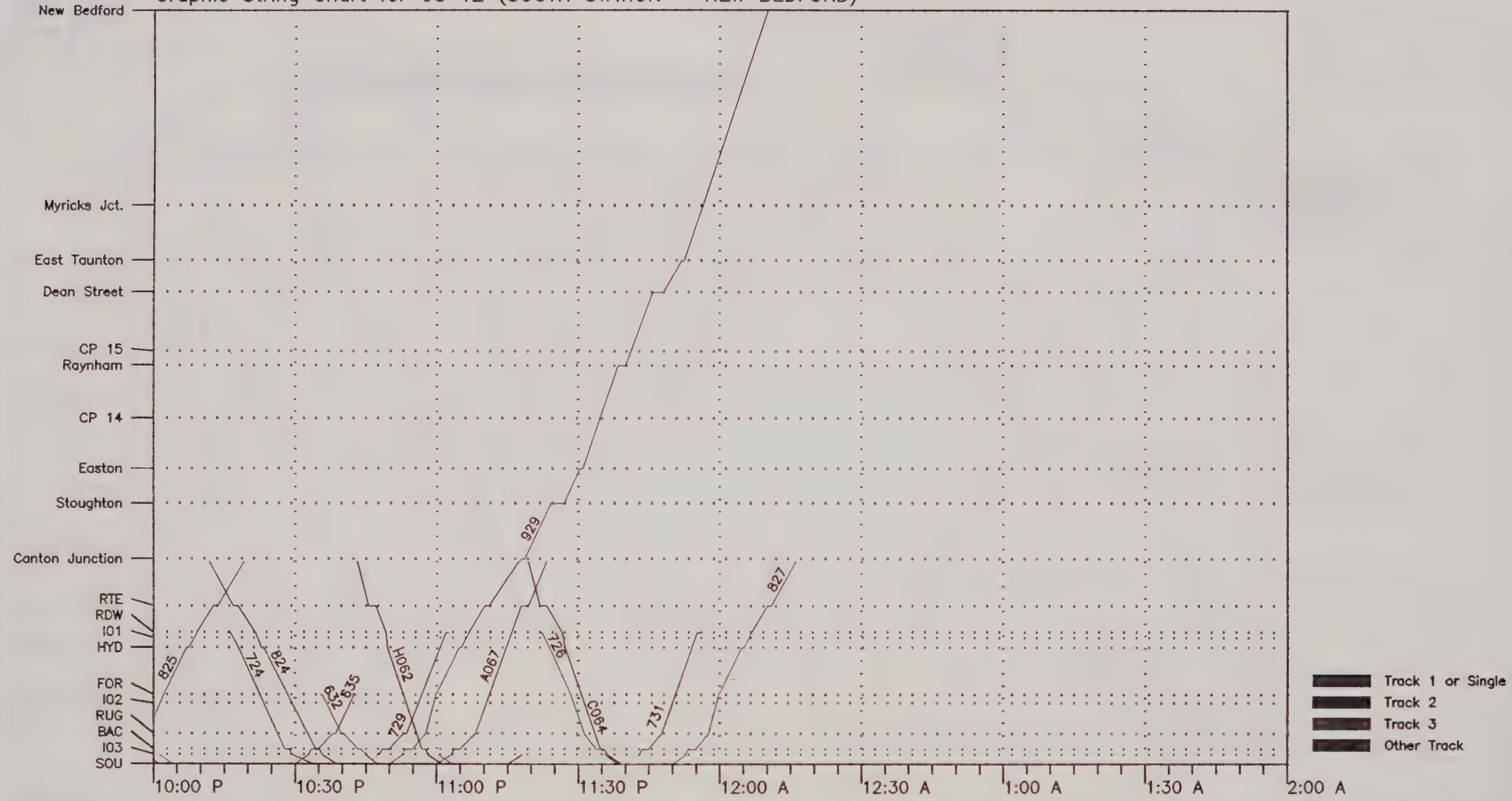
MBTA Fall River/New Bedford Simulation

Graphic String Chart for GS 12 (SOUTH STATION – NEW BEDFORD)



Massachusetts
Bay
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New Bedford / Fall River Commuter Rail

OPERATIONS SIMULATION REPORT

Figure 6

New Bedford to South Station String Chart

10:00PM TO 2:00AM

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Sheet 5 of 5

SCALE NTS

DATE Jan. 18, 1999

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The most vital capital projects coming to the Northeast Corridor are those that make possible a 150 mph Maximum Authorized Speed (MAS). To attain that speed, Amtrak is extending electrification (the overhead catenary from which electric locomotives collect power) from New Haven to Boston. High-speed trainsets have been ordered to protect advertised three-hour schedules between New York Penn Station and Back Bay. In addition, the signal system on the Corridor is being upgraded to a dual-frequency system with nine code rates ("speed commands") that will support 150-mph operations. It will enable the high-speed trains to achieve their potential wherever conditions permit, while safely separating them from slower trains that will share the railroad.

The nine code rates will be as follows:

Stop/Restricting (No Code)
Approach - 30 mph (75 ppm)
Approach Medium - 30 mph (75 ppm/75 ppm)
Approach Limited - 45 mph (120 ppm)
CS 60 - 60 mph
CS 80 - 80 mph
CS 100 -100 mph
C 125 – 125 mph
C 150 – 150 mph

All nine-code rates will not necessarily be active at all locations. This is due to design issues involving the maximum safe diverging speed through each turnout, civil speed restrictions, and safe braking distance criteria.

The new cab signal system has important implications for capacity and throughput. Signaling tracks for 150 mph stretches the distance required for safe braking. Longer control lines needed to provide safe braking distance for high-speed trains increases signal clearing time for following trains. Longer headways are required between high-speed trains and preceding rail traffic to avoid cab signal speed reductions.

MBTA diesel-powered trains have a practical top speed of about 80 miles-per-hour, depending on the number of coaches being handled in the consist. Therefore, if MBTA trains are equipped only with the existing conventional on-board Cab Signal equipment and therefore cannot interpret the 9-Aspect ATC System, MBTA trains will interpret CS 80 as 45 miles per hour instead of 80 miles per hour. Clearly, this is very significant.

- An analysis was conducted using the RAILSIM New Bedford/Fall River simulation to predict the effect on MBTA and Amtrak operations inbound to Boston if MBTA trains operating on the Northeast Corridor were all equipped with on-board ATC equipment capable of interpreting the 9-Aspect system. This would mean that MBTA trains could interpret a CS 80 code as 80 mph (instead of a "default" 45 mph). The exercise revealed that although signal delay was almost unaffected, on-time performance was materially improved for both MBTA and Amtrak.

The following Lateness Distribution at South Station reveals this result. Compare this result with the results in **Table 12** for the deterministic ("ideal") simulation, noting that *no intervention was undertaken to further improve or "tweak" the simulation once the 9-Aspect Cab Signal System was activated for MBTA trains.*

The number of trains arriving on time or early increased from 59 (out of 147) to 75 (out of 147). Only 6 trains were more than four minutes late compared with 10 trains more than four minutes late in the baseline simulation. The total cumulative lateness of *all* trains was cut by almost half from 43 minutes to just 26 minutes. The average lateness of *all* trains was reduced by 75% from 43 seconds to just 11 seconds. The average lateness of late trains (giving no "credit" for early arrivals) fell only by 9 seconds -- from 1 minute 55 seconds to 1 minutes 46 seconds -- only because of one very late train, Train 044, which still arrived 6 minutes 15 seconds late. As this is an Old Colony train, it was unaffected by the 9-Aspect system.

Table 36

```
Lateness Report, 9-Aspect ATC/CSS active for MBTA
Station: SOUTH STATION
Lateness distribution:           Cnt     Pct.    Cum    Pct.

                              -------- Eastbound only --------
5:01 or more minutes early         2      1.4       2     1.4
4:01 - 5:00 minutes early          2      1.4       4     2.7
3:01 - 4:00 minutes early          2      1.4       6     4.1
2:01 - 3:00 minutes early          7      4.8      13     8.8
1:01 - 2:00 minutes early         27     18.4      40    27.2
0:01 - 1:00 minutes early         34     23.1      74    50.3
On time                            2      1.4      76    51.7
0:01 - 1:00 minutes late          30     20.4     106    72.1
1:01 - 2:00 minutes late          16     10.9     122    83.0
2:01 - 3:00 minutes late           8      5.4     130    88.4
3:01 - 4:00 minutes late          11      7.5     141    95.9
4:01 - 5:00 minutes late           4      2.7     145    98.6
5:01 - 6:00 minutes late           1      0.7     146    99.3
6:01 - 7:00 minutes late           1      0.7     147   100.0
7:01 - 8:00 minutes late           0      0.0     147   100.0
8:01 - 9:00 minutes late           0      0.0     147   100.0
9:01 - 10:00 minutes late          0      0.0     147   100.0
10:01 or more minutes late         0      0.0     147   100.0

Total lateness, all trains       147                    26:12
Average lateness, all trains     147                    00:11
Average lateness, late trains     71                    01:46
Latest Train:       044                                 06:15
```

Accrued signal delay is not materially affected by an inability of MBTA trains to interpret CS 80 because there are very few locations where CS 80 is the best aspect. If CS 80 is *not* the best available code rate at a particular location, the simulator will log a signal delay event whether MBTA trains can interpret CS 80 or not. However, the effect of operating at 45 mph instead of 80 mph has a material effect on performance relative to schedule and may affect any trains following closely enough to be delayed by the "slow" MBTA train.

- It is important to state that the proforma Operating Plans for Amtrak and MBTA operations circa 2000-2002 originally assumed that all Amtrak and MBTA trains operating on any part of the Northeast Corridor would be able to interpret the 9-Aspect system. Accordingly, the Operating Plan is "tuned" for the point-to-point running times that are achievable with this system under practical operating conditions.

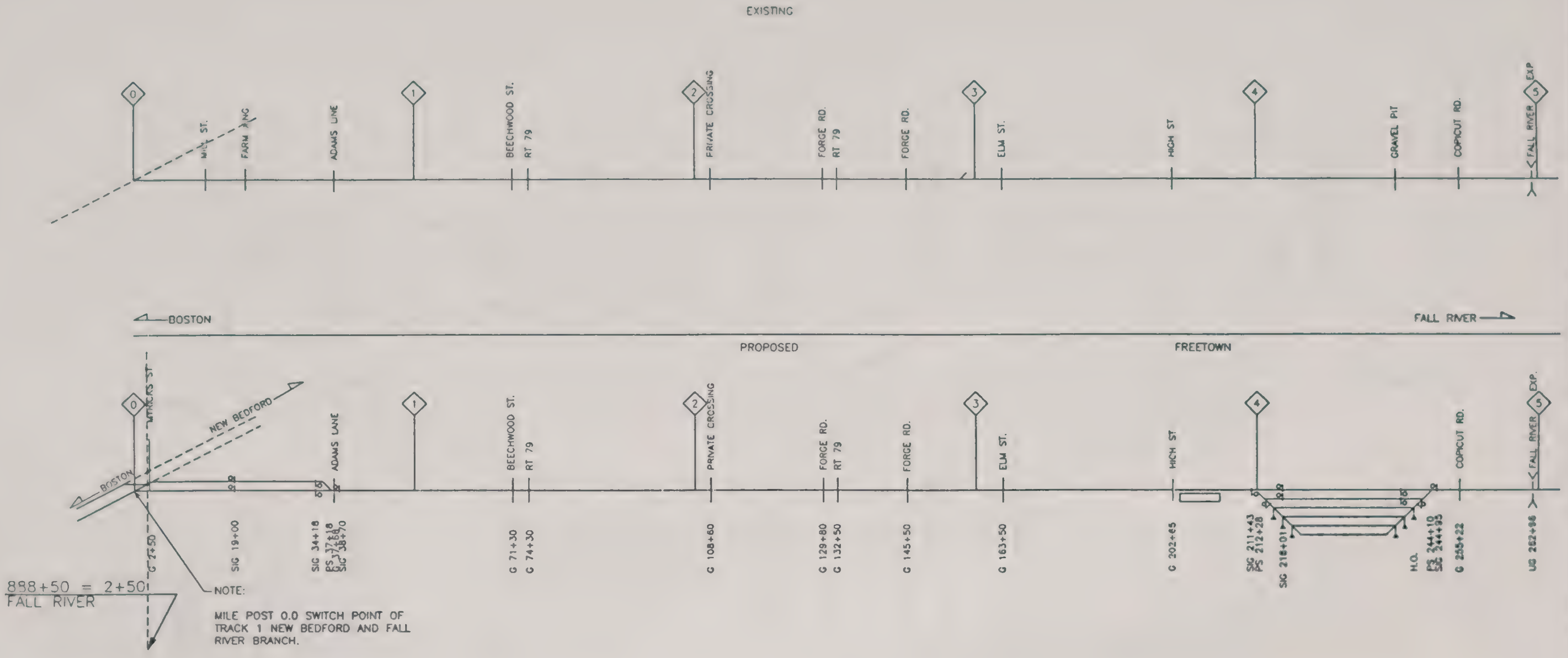
Previous simulation work carried out for the Alternatives Analysis of extending the Stoughton Branch to Fall River and New Bedford was done with a Year 2010 scenario in mind. This assumed that the MBTA would have installed the 9-Aspect cab signal pick-up on its equipment. The present analysis could not work under such an assumption. The difference between the two simulations (work done in 1996-7 compared to the present analysis) is striking. Despite the earlier simulation effort having involved less extensive fine-tuning of the model, it created a more stable rail operation.

Schedules for all MBTA routes using the Corridor (except Needham with the shortest segment) had to be lengthened from those used in the Alternatives Analysis simulation and even from present schedules. Efforts to cross over as many inbound morning-peak Providence and Fall River/New Bedford trains as possible to NEC Track 3 to enable service to Ruggles Street went awry and had to be eliminated because the reduced-speed movements through the turnouts caused ripple-effect delays to following trains.

In the evening peak, the lack of 9-Aspect pick-up on MBTA trains contributes to delays to both Amtrak and MBTA trains in the Transfer Interlocking/Route 128/Canton Junction segment. If Amtrak trains receive first access to Route 128, the following MBTA trains merging from the present end of Track 3 at Transfer Interlocking may receive significant delays. If MBTA trains are moved first, Amtrak trains receive signal delay and are late arriving at Route 128 station, as the commuter trains are slowly taking the Canton Junction crossovers.

APPENDIX A

SINGLE LINE TRACK CHART



NOTE:

MILE POST 0.0 SWITCH POINT OF TRACK 1 NEW BEDFORD AND FALL RIVER BRANCH.

BASED ON FALL RIVER CHAINAGE

PRIMARY USEAGE

- —— PASSENGER / FREIGHT
- —— FREIGHT
- —— PASSENGER
- - - - DASHED REFERENCED TRACK

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

NEW BEDFORD/FALL RIVER
COMMUTER RAIL PROJECT
CONTRACT NO.X2PS68

FALL RIVER
PRELIMINARY TRACK LAYOUT

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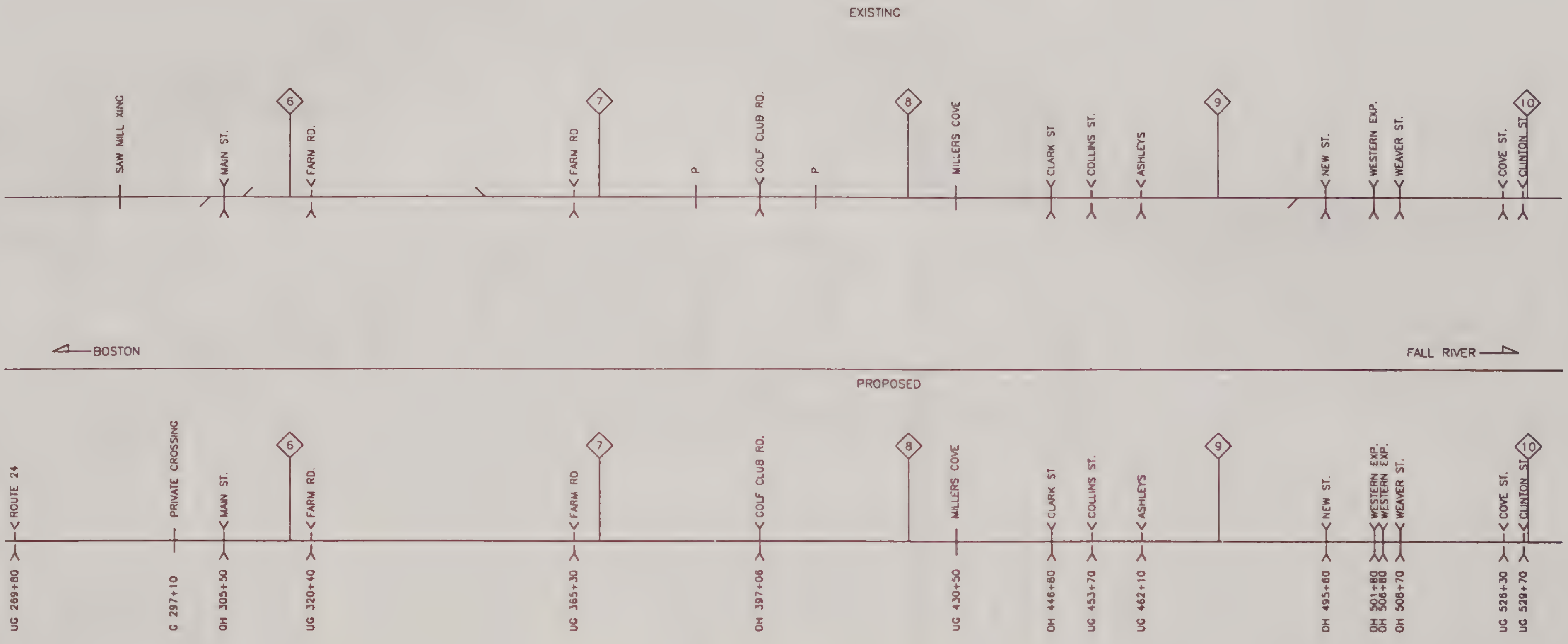

BASED ON FALL RIVER CHAINAGE

PRIMARY USEAGE

- PASSENGER / FREIGHT
- FREIGHT
- PASSENGER
- DASHED REFERENCED TRACK

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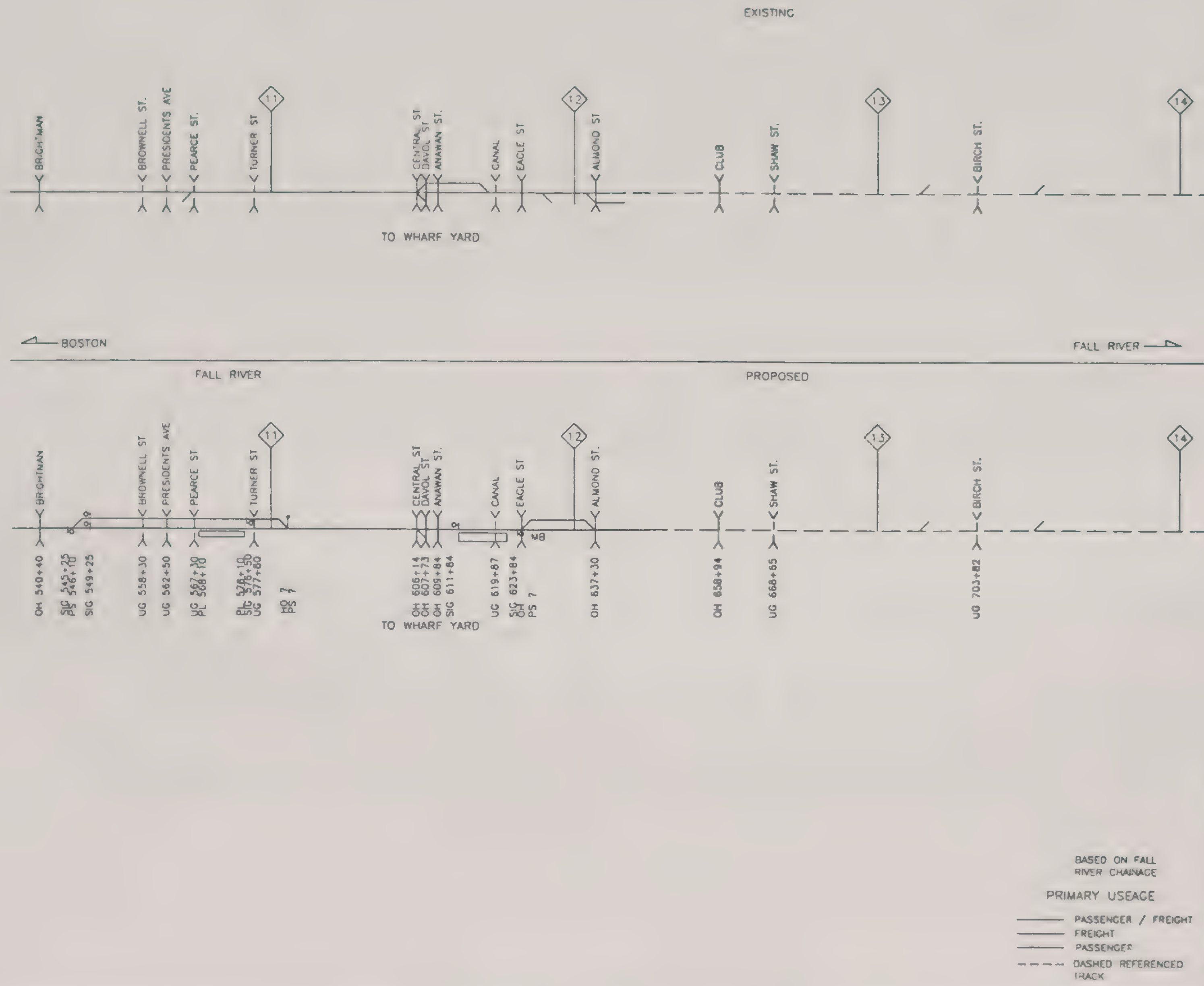

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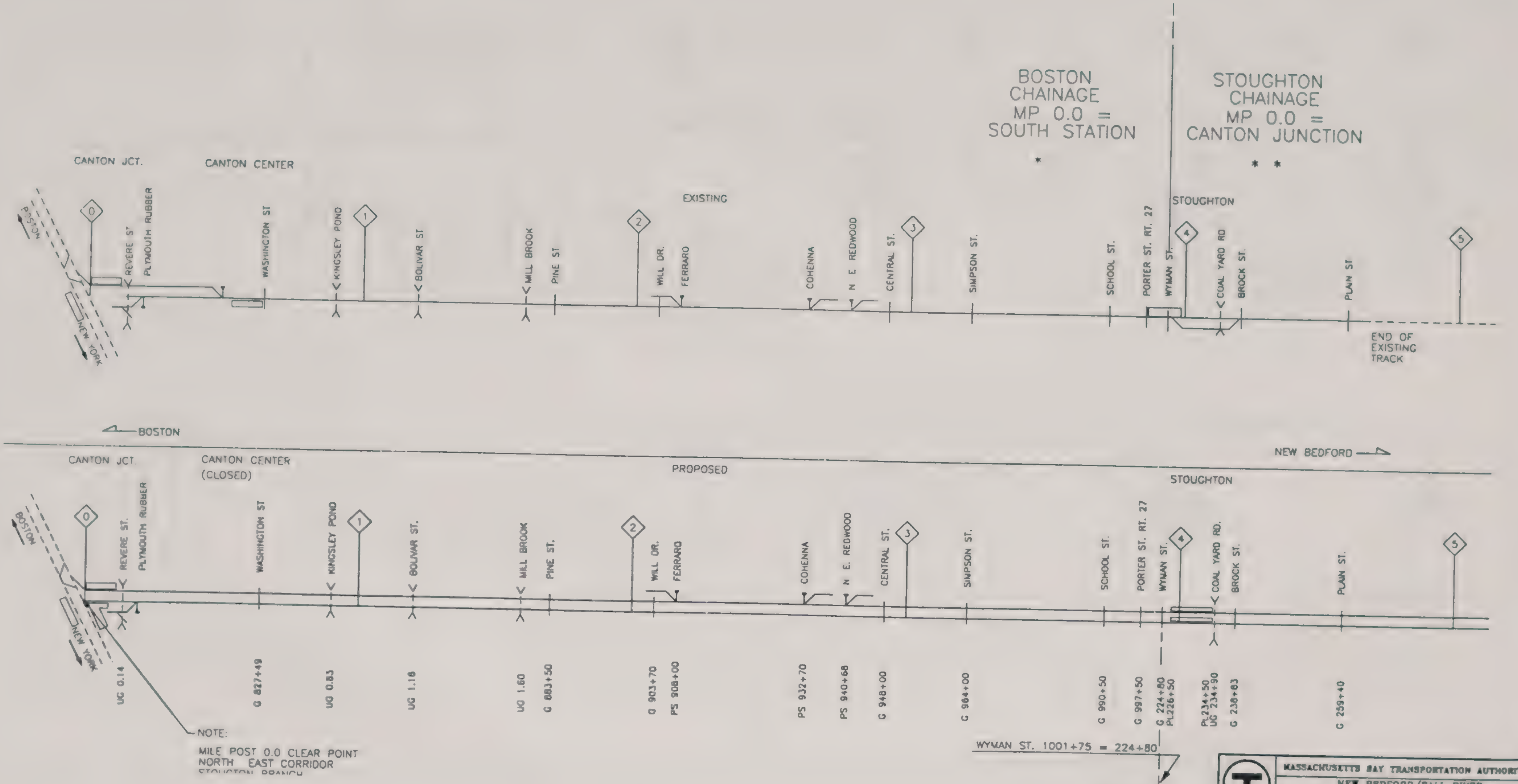

- * BASED ON SOUTH STATION CHAINAGE
- * * BASED ON CANTON JUNCTION CHAINAGE

PRIMARY USEACE

———	PASSENGER / FREIGHT
———	FREIGHT
———	PASSENGER
- - - -	DASHED REFERENCED TRACK

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NEW BEDFORD
PRELIMINARY TRACK LAYOUT

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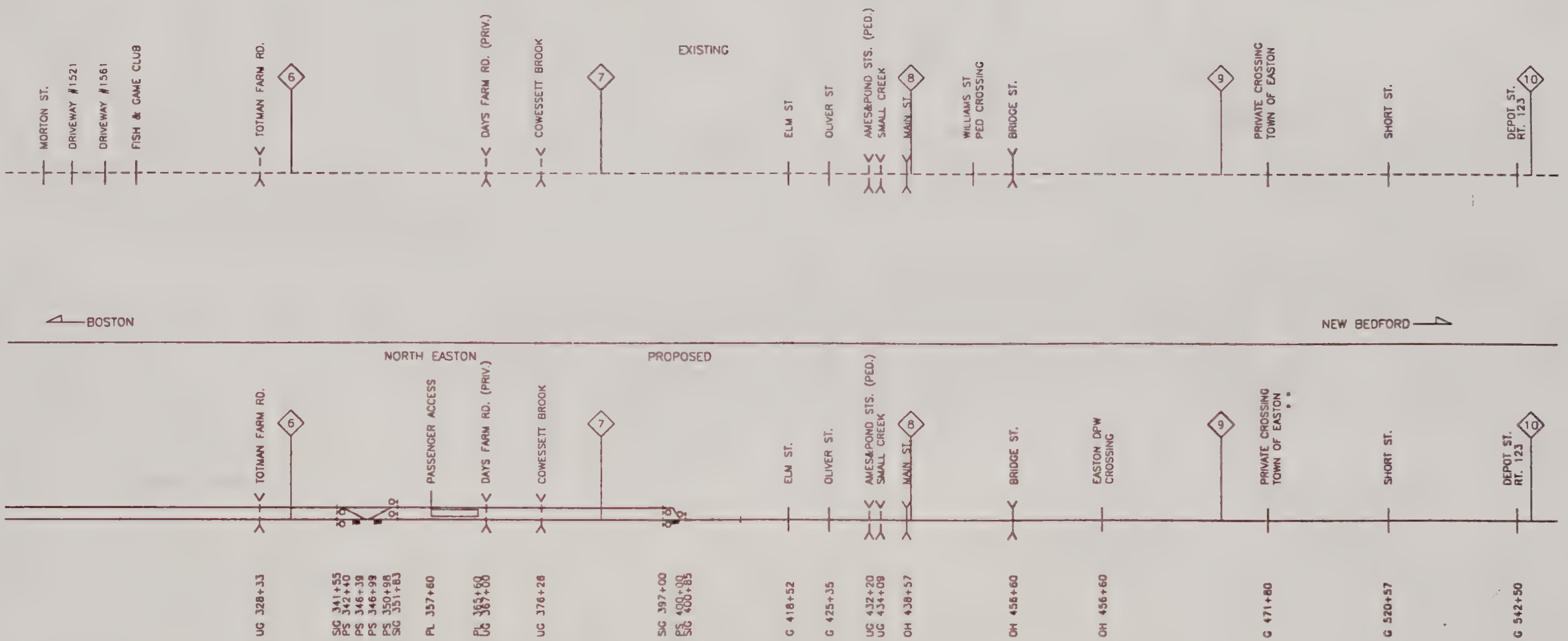

BASED ON CANTON
JUNCTION CHAINAGE
• • GATED & LOCKED

PRIMARY USEAGE

- PASSENGER / FREIGHT
- FREIGHT
- PASSENGER
- DASHED REFERENCED TRACK

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NEW BEDFORD/FALL RIVER
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NEW BEDFORD
PRELIMINARY TRACK LAYOUT

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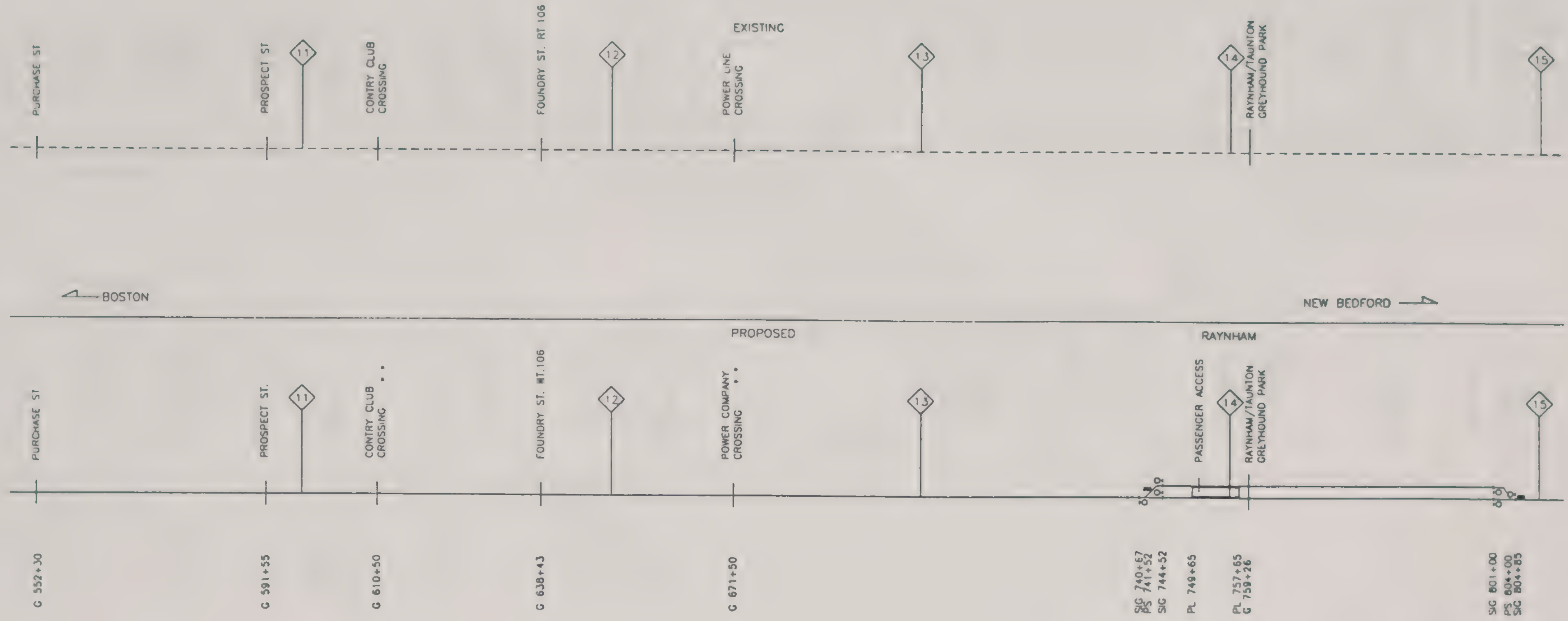

BASED ON CANTON JUNCTION CHAINAGE
• • GATED & LOCKED

PRIMARY USEAGE

——— PASSENGER / FREIGHT
——— FREIGHT
——— PASSENGER
- - - - DASHED REFERENCED TRACK

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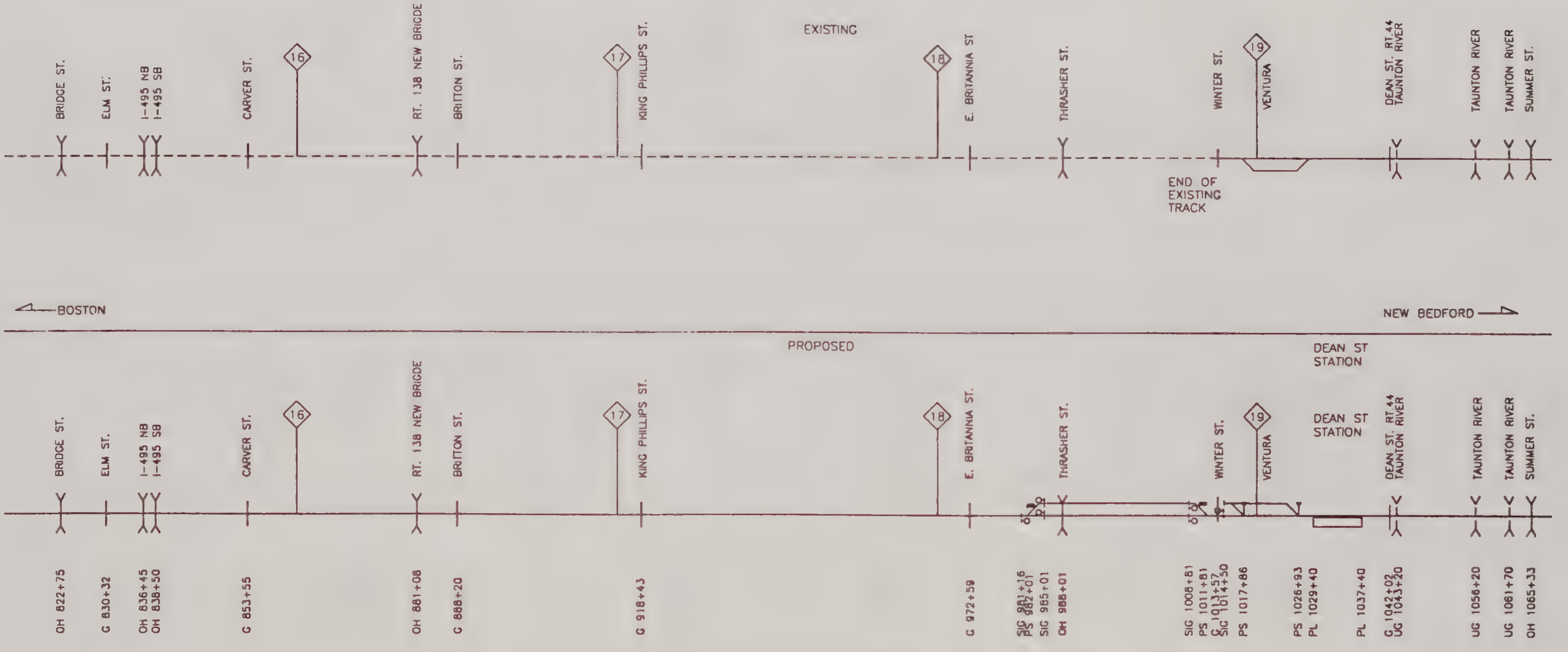

BASED ON CANTON
JUNCTION CHAINAGE

PRIMARY USEAGE

—— PASSENGER / FREIGHT
—— FREIGHT
—— PASSENGER
- - - - DASHED REFERENCED TRACK

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
NEW BEDFORD/FALL RIVER
COMMUTER RAIL PROJECT
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NEW BEDFORD
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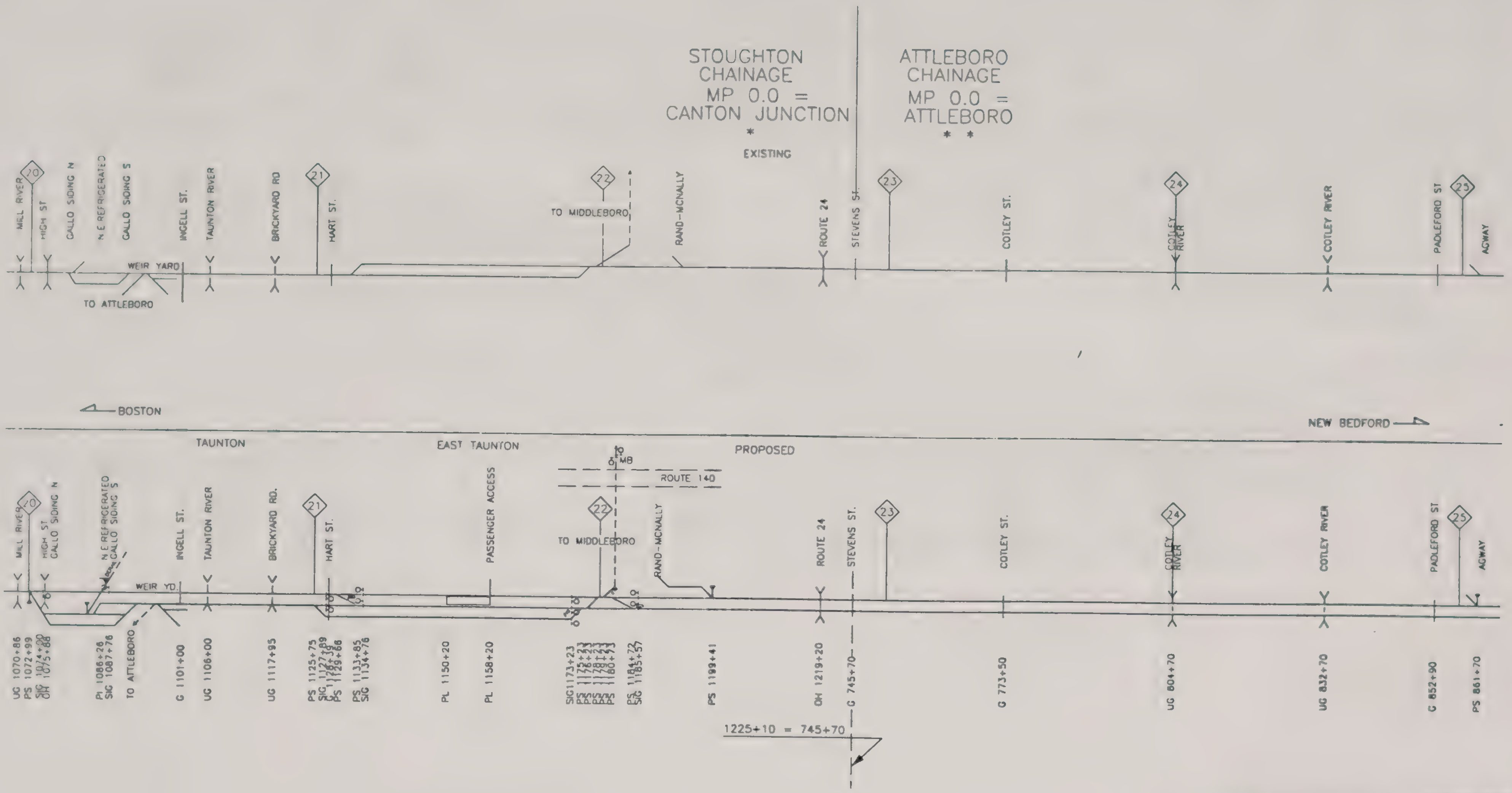

- • BASED ON CANTON JUNCTION CHAINAGE
- • • BASED ON ATTLEBORO CHAINAGE

PRIMARY USEAGE

- —— PASSENGER / FREIGHT
- —— FREIGHT
- —— PASSENGER
- - - - DASHED REFERENCED TRACK

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

NEW BEDFORD/FALL RIVER
COMMUTER RAIL PROJECT
CONTRACT NO.X2PS66

NEW BEDFORD
PRELIMINARY TRACK LAYOUT

SYSTRA CONSULTING
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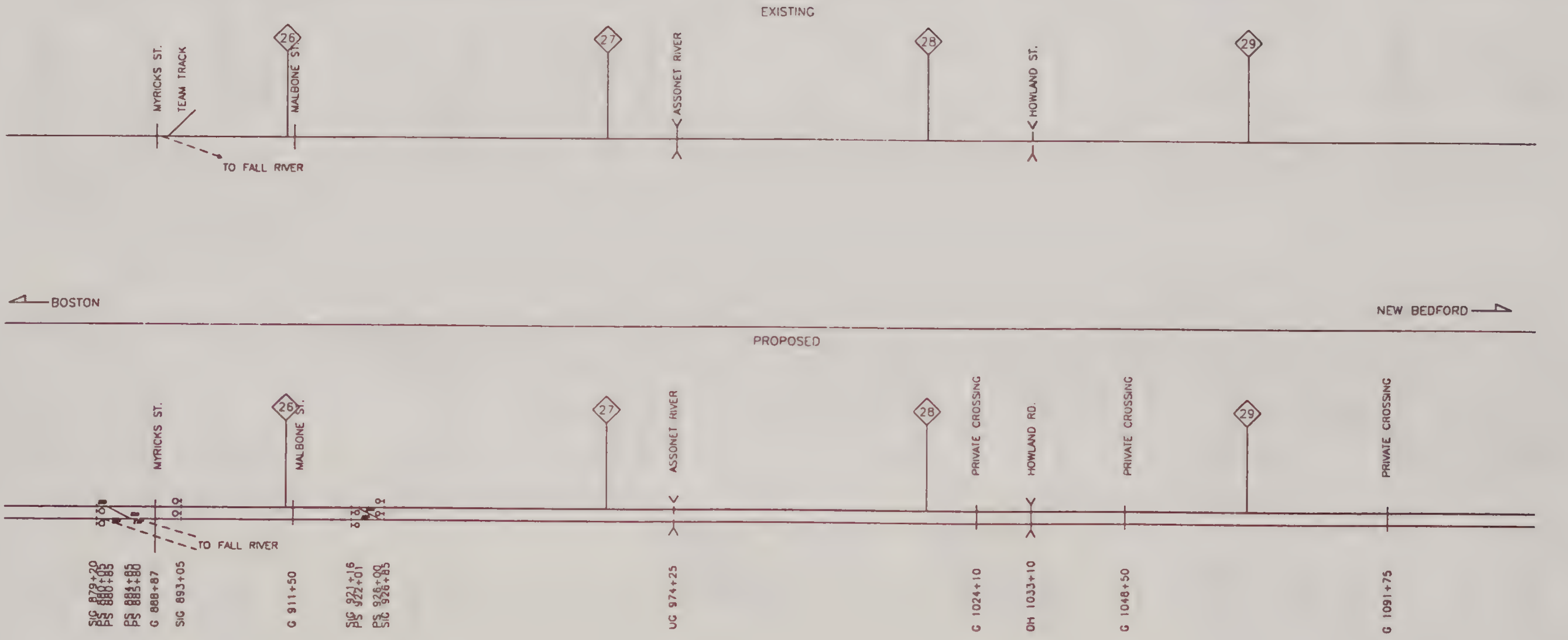

BASED ON ATTLEBORO CHAINAGE

PRIMARY USEAGE

——	PASSENGER / FREIGHT
——	FREIGHT
——	PASSENGER
- - - -	DASHED REFERENCED TRACK

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

NEW BEDFORD/FALL RIVER
COMMUTER RAIL PROJECT
CONTRACT NO.X2PS68

NEW BEDFORD
PRELIMINARY TRACK LAYOUT

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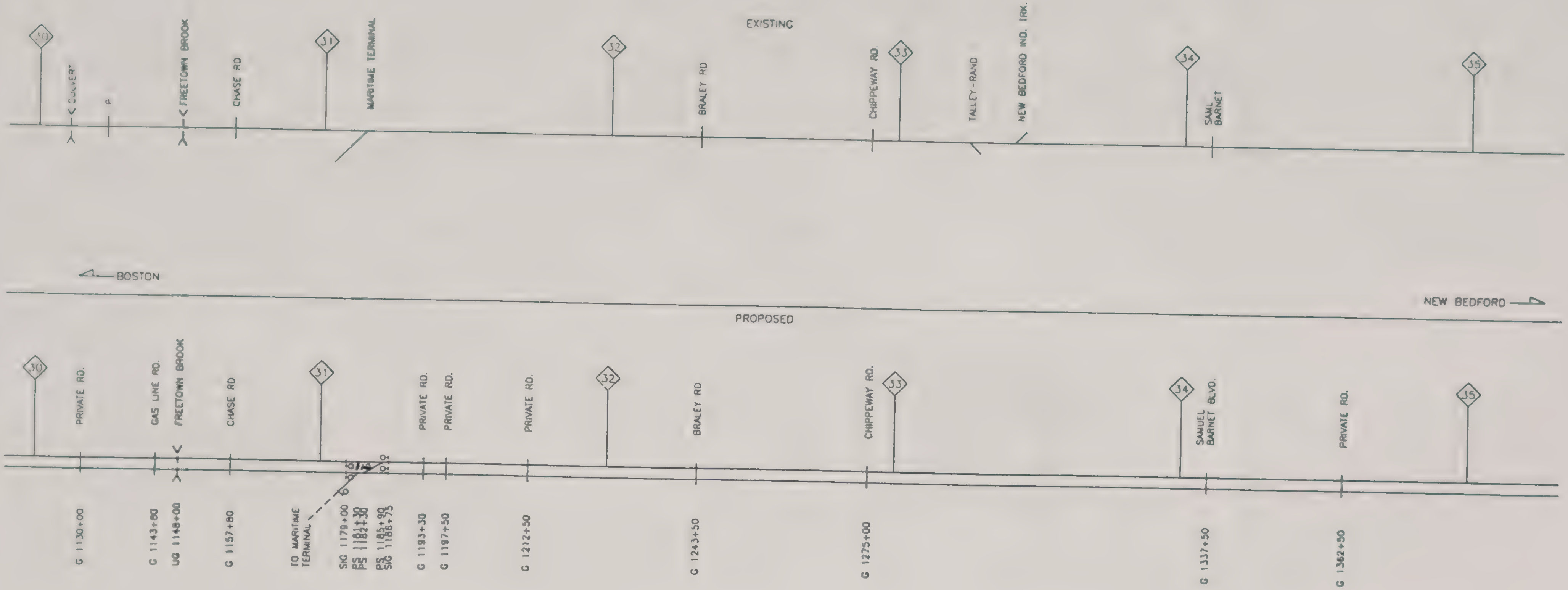

BASED ON ATTLEBORO
CHAINAGE

PRIMARY USEAGE

- ——— PASSENGER / FREIGHT
- ——— FREIGHT
- ——— PASSENGER
- - - - DASHED REFERENCED TRACK

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NEW BEDFORD
PRELIMINARY TRACK LAYOUT

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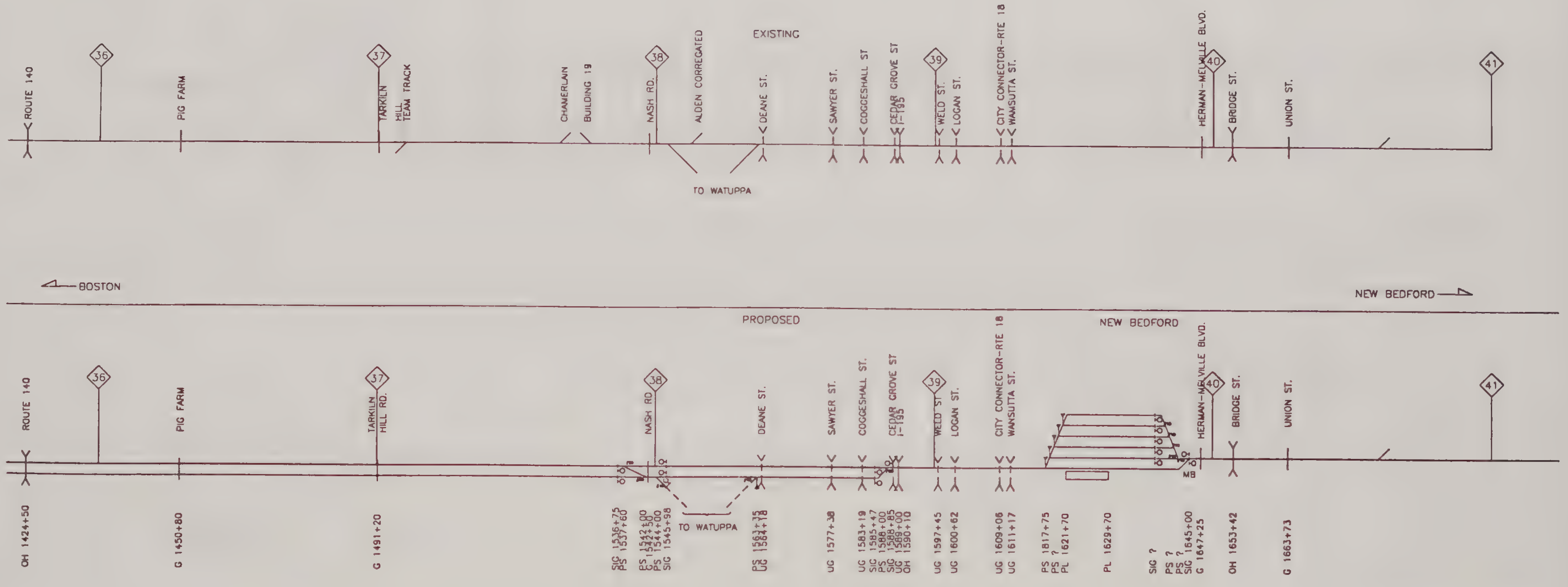
MASS BAY TRANSPORTATION AUTHORITY
APPROVED BY

PROJECT MANAGER

SCALE: NO SCALE	DESIGN BY:	DRAWN BY:	CHECK BY:	PLAN NO. NB300.007	ISSUE
DATE: 1/14/99	PCX	EJO'S	TJB	SHEET 7 OF 8	△



BASED ON ATTLEBORO CHAINAGE

PRIMARY USEAGE

- ——— PASSENGER / FREIGHT
- ——— FREIGHT
- ——— PASSENGER
- – – – – DASHED REFFRENCED TRACK

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
NEW BEDFORD/FALL RIVER
COMMUTER RAIL PROJECT
CONTRACT NO.X2PS68

NEW BEDFORD
PRELIMINARY TRACK LAYOUT

SYSTRA CONSULTING
38 Chauncy Street
Suite 805
Boston, MA 02111

VHB

MASS. BAY TRANSPORTATION AUTHORITY
APPROVED BY

PROJECT MANAGER

SCALE: NO SCALE	DESIGN BY:	DRAWN BY:	CHECK BY:	PLAN NO. NB360.008	ISSUE
DATE: 1/14/99	PCX	EJO'B	TJB	SHEET 8 OF 8	1

Attleboro Alternative Operations Analysis
August 1995

Attleboro Line
Operational Analysis

MEMORANDUM

TO: SAB Engineering & Construction, Inc.

FROM: Susan G. Beetle

DATE: 15 August 1995

RE: MBTA New Bedford Service Restoration: Preliminary Performance Results

I am enclosing the results of preliminary performance runs for the New Bedford branch line. The four runs analyze northbound and southbound movements between the main line junction and New Bedford and between the main line junction and Fall River. For each run, a tabular summary of performance and a set of graphs showing the train speed profile between stations is included.

Several caveats must be mentioned. Foremost, we do not know the specifics of locomotives and coaches to be used on the line. Copies of the equipment characteristics files used in the runs are enclosed. The performance results pertain to these equipment types, and might differ if we had more precise information on the rolling stock intended for the New Bedford service.

Second, a 79 mph speed limit has been used over the routes, restricted only through some curves and in areas with multiple grade crossings. Track improvements and increased superelevation on curves would be needed to support the speeds attained in the runs. We are checking the superelevation adjustments needed for the existing curvature and will advise shortly. the track engineers may want to do the same, and consider as well the speed restrictions that may have to continue in the absence of major curves easement.

Third, the locations of stations are estimated. We request improved data in each of these areas as soon as they can be supplied.

Given these conditions, the runs show one-way times of 43 to 46 minutes on the New Bedford route and 53 to 54 minutes on the Fall River route. With the equipment and speed restrictions used in the runs, the 79 mph maximum speed is achieved only at one location. The average commercial speed for the New Bedford route is 40 mph; for the Fall River route, 32 mph.

On the basis of these performance results, I am proceeding to develop information on safe separations and headway capabilities for the New Bedford branch. These results will follow.

GBC Systems, Inc.

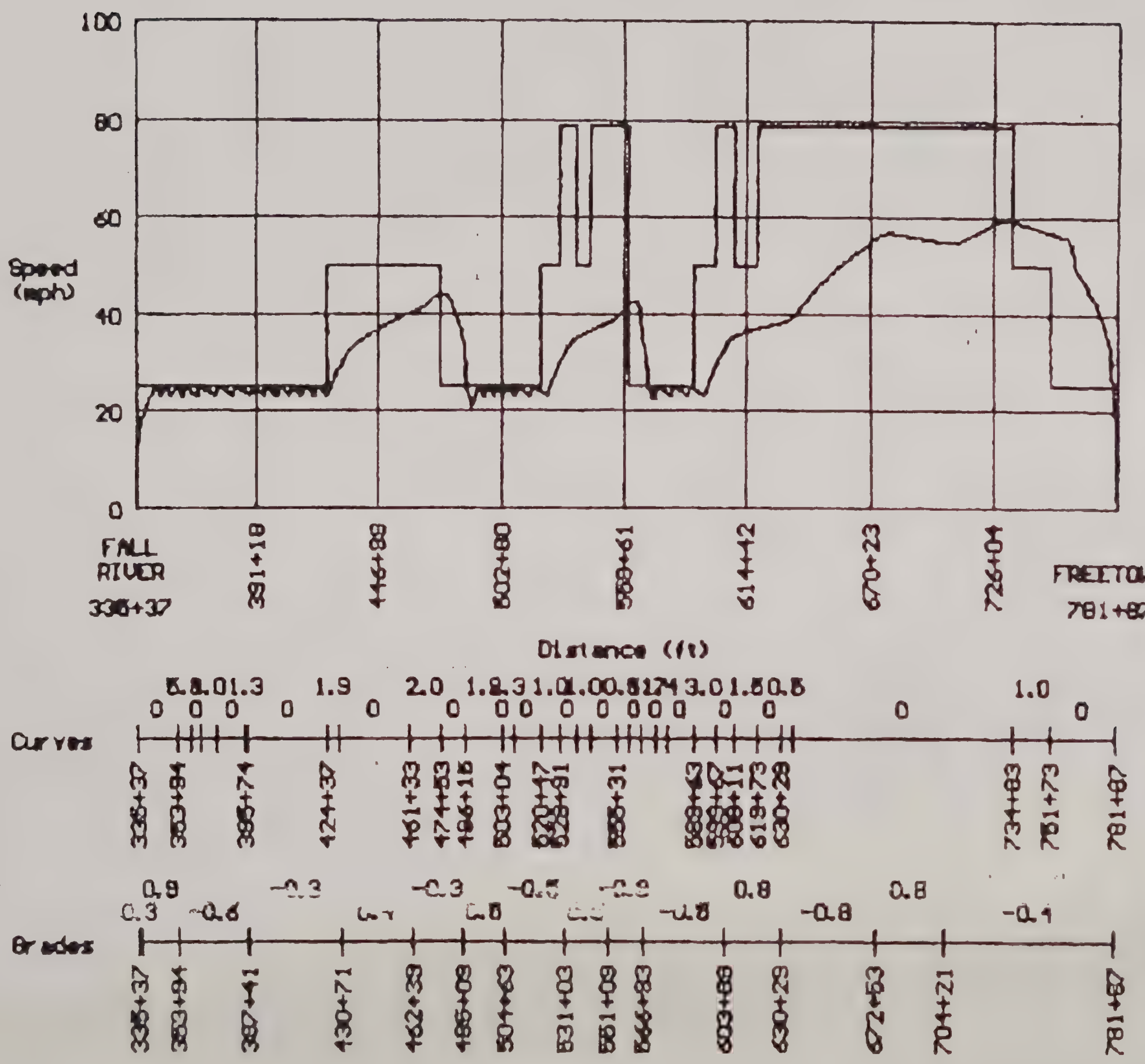
TRAIN PERFORMANCE

```
MBTA CMMTR RAIL. VHB ENGNRNG: SAB                               9504-101
PRLMNRY PSSNGR SRVC PRFRMNC NB               LOCOPRFM          14 AUG 95
MAIN LINE JUNCTION-FALL RIVER              VRSN 30 JUN 91            SGB


PROFILE TABLE               PFMLFRPN          1  LOCO UNITS/TRAIN
PSSNGR/FRGHT STTNS FILE     PSMLFRPN          8  PSSNGR CARS/TRAIN
LOCO CHARACTERISTICS FILE   MBNBPPLC
CAR CHARACTERISTICS FILE    MBNBPPCR        130  PASSENGERS/CAR


AVG LOADED CAR        127.500 LBS.       TRN WEIGHT      707.15 TONS


ORIGIN:  FALL RIVER                 DSTNTN:  ML-BRNCH JUNCTION


              PASSENGER                           CENTERLINE
               STATION                             LOCATION
              ---------                           ----------

           FALL RIVER                                331+63
           FREETOWN                                  778+13
           EAST TAUNTON                             1185+83
           TAUNTON CENTER                           1301+97
           ML-BRNCH JUNCTION                        1868+64
```

TRAIN PERFORMANCE

```
MBTA CMMTR RAIL. VHB ENGNRNG: SAB                            9504-101
PRLMNRY PSSNGR SRVC PRFRMNC NB              LOCOPRFM        14 AUG 95
MAIN LINE JUNCTION-FALL RIVER             VRSN 30 JUN 91          SGB

                     MAXIMUM                AVERAGE             AVERAGE
                      SPEED     RUNNING     RUNNING    DWELL    INTRSTTN
      STATION        REACHED     TIME        SPEED     TIME      SPEED
 ----------------    -------   ---------   --------    ----    -------
                      (MPH)    (MIN:SEC)    (MPH)      (SEC)     (MPH)

FALL RIVER             0.0        0:00        0.0         0       0.0
FREETOWN              59.8       15:29       32.7        60      30.7
EAST TAUNTON          59.2       12:40       36.5        60      33.9
TAUNTON CENTER        25.0        5:46       22.9        60      19.5
MI-BRNCH JUNCTION     40.2       16:20       39.4         0      39.4
                                --------               -----
   TOTALS                        50:14                  180

        DEPARTURE-ARRIVAL TIME   =  53  MINUTES,  14  SECONDS

        TOTAL TRIP LENGTH        =  29.11  MILES
        AVG. COMMERCIAL SPEED    =  32.8   MPH
```

PRLMNRY PSSNGR SRVC PRFRMNC NB
MAIN LINE JUNCTION-FALL RIVER



SPEED/DISTANCE

CAR FILE: MBNBPPCR

CARS: 8

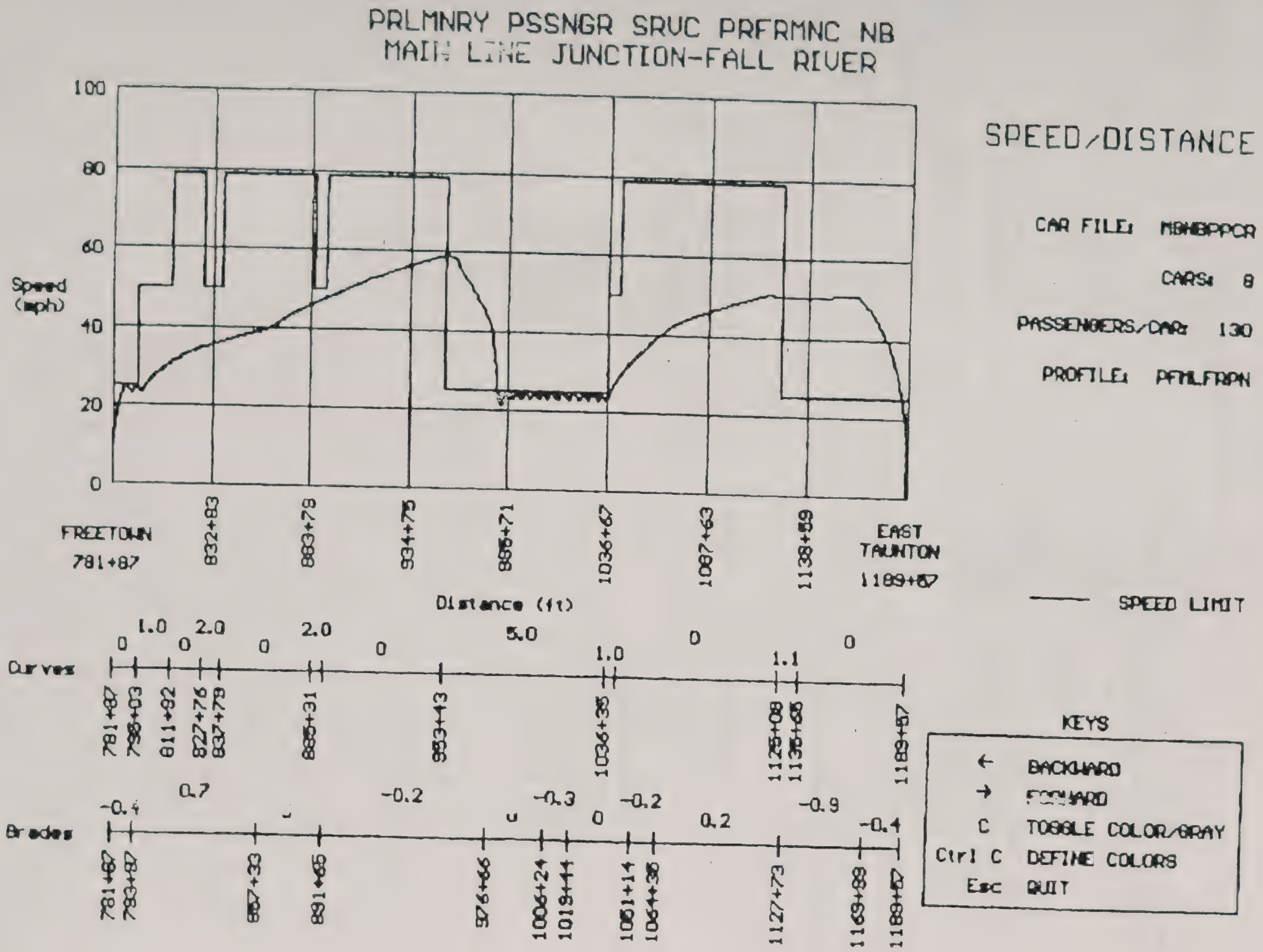
PASSENGERS/CAR: 130

PROFILE: PFMLFRPN

—— SPEED LIMIT

KEYS

←	BACKWARD
→	FORWARD
C	TOGGLE COLOR/GRAY
Ctrl C	DEFINE COLORS
Esc	QUIT



PRLMNRY PSSNGR SRVC PRFRMNC NB
MAIN LINE JUNCTION-FALL RIVER

SPEED/DISTANCE

CAR FILE: MBNBPPCR

CARS: 8

PASSENGERS/CAR: 130

PROFILE: PFMLFRPN

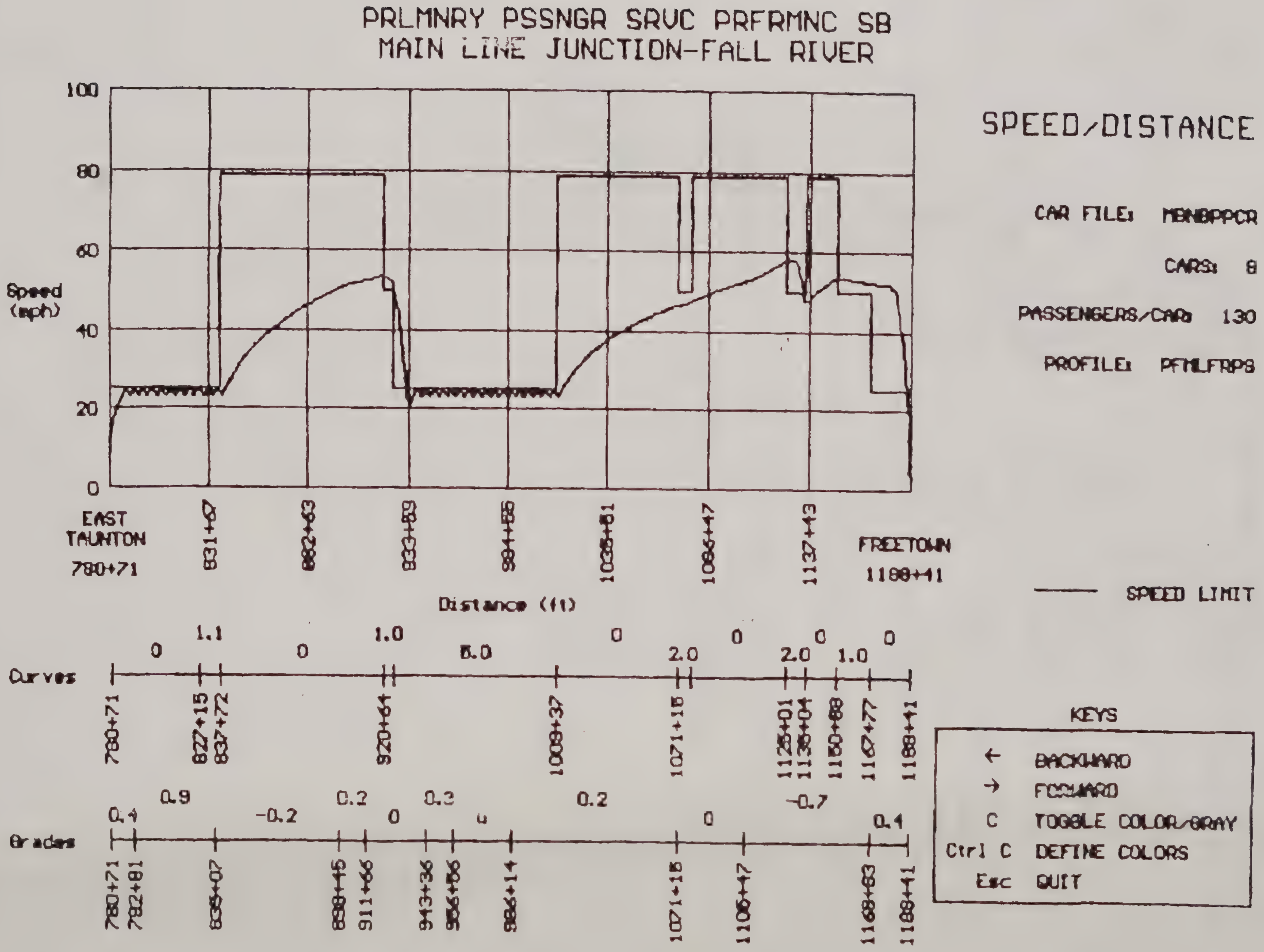
KEYS

← BACKWARD
→ FORWARD
C TOGGLE COLOR/GRAY
Ctrl C DEFINE COLORS
Esc QUIT

```
                         TRAIN PERFORMANCE

MBTA CMMTR RAIL. VHB ENGNRNG: SAB
PRLMNRY PSSNGR SRVC PRFRMNC SB                               9504-101
MAIN LINE JUNCTION-FALL RIVER                 LOCOPRFM      14 AUG 95
                                          VRSN 30 JUN 91          3G8

PROFILE TABLE                  PFMLFRPS           1  LOCO UNITS/TRAIN
PSSNGR/FRGHT STTNS FILE        PSMLFRPS           8  PSSNGR CARS/TRAIN
LOCO CHARACTERISTICS FILE      MBNBPPLC
CAR CHARACTERISTICS FILE       MBNBPPCR         130  PASSENGERS/CAR

AVG LOADED CAR        127.500 LBS.          TRN WEIGHT      707.15 TONS

ORIGIN:   ML-BRNCH JUNCTION            DSTNTN:  FALL RIVER


                PASSENGER                          CENTERLINE
                 STATION                            LOCATION
                ---------                          ----------

            ML-BRNCH JUNCTION                         94+16
            TAUNTON CENTER                           660+83
            EAST TAUNTON                             776+97
            FREETOWN                                1184+67
            FALL RIVER                              1631+17
```

TRAIN PERFORMANCE

```
MBTA CMMTR RAIL. VHB ENGNRNG: SAB                                9504-101
PRLMNRY PSSNGR SRVC PRFRMNC SB                 LOCOPRFM         14 AUG 95
MAIN LINE JUNCTION-FALL RIVER                VRSN 30 JUN 91           SGB

                      MAXIMUM                   AVERAGE                AVERAGE
                       SPEED       RUNNING      RUNNING     DWELL     INTR STTN
    STATION           REACHED       TIME         SPEED       TIME       SPEED
----------------      -------    ----------     -------     -----     ---------
                       (MPH)     (MIN:SEC)       (MPH)      (SEC)       (MPH)

ML-BRNCH JUNCTION       0.0         0:00          0.0         0          0.0
TAUNTON CENTER         71.2        14:53         43.2        60         40.5
EAST TAUNTON           25.0         5:46         22.8        60         19.4
FREETOWN               58.1        13:48         33.5        60         31.2
FALL RIVER             55.1        16:10         31.3         0         31.3
                                  ------                    -----
   TOTALS                          50:37                     180

         DEPARTURE-ARRIVAL TIME    =  53  MINUTES.  37  SECONDS

         TOTAL TRIP LENGTH         =  29.11  MILES
         AVG. COMMERCIAL SPEED     =  32.5   MPH
```



PRLMNRY PSSNGR SRVC PRFRMNC SB
MAIN LINE JUNCTION-FALL RIVER

SPEED/DISTANCE

CAR FILE: MBNBPPCR

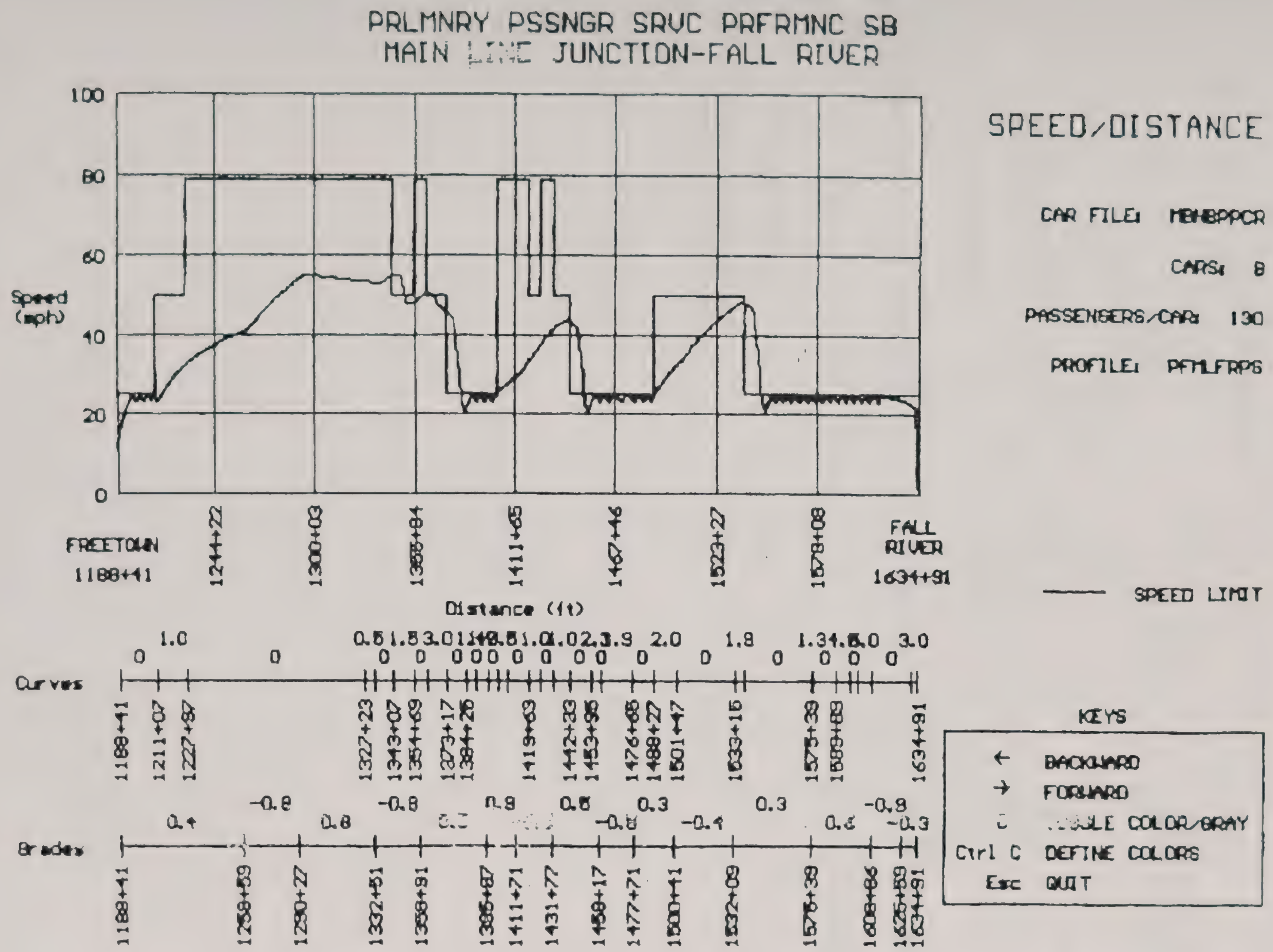
CARS: 8

PASSENGERS/CAR: 130

PROFILE: PFMLFRPS

KEYS

←	BACKWARD
→	FORWARD
C	TOGGLE COLOR/GRAY
Ctrl C	DEFINE COLORS
Esc	QUIT



PRLMNRY PSSNGR SRVC PRFRMNC SB
MAIN LINE JUNCTION-FALL RIVER

SPEED/DISTANCE

CAR FILE: MBHBPPCR

CARS: 8

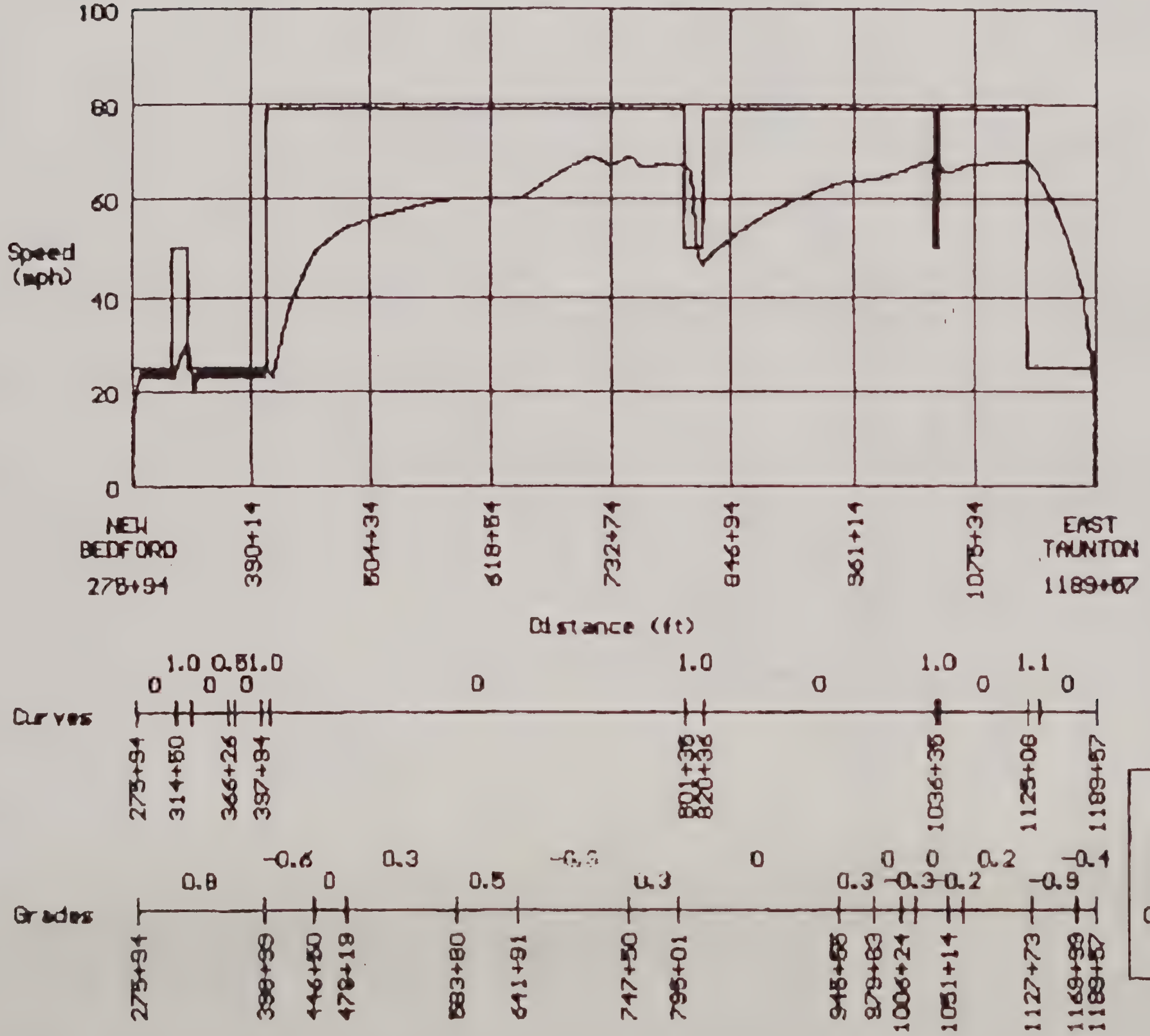
PASSENGERS/CAR: 130

PROFILE: PFMLFRPS

```
                    TRAIN  PERFORMANCE

MBTA CMMTR RAIL. VHB ENGNRNG. SAB                             9504-101
PRLMNRY PSSNGR SRVC PRFRMNC NB              LOCOPRFM        14 AUG 95
MAIN LINE JUNCTION-NEW BEDFORD            VRSN 30 JUN 91          SGB


PROFILE TABLE               PFMLNBPN            1  LOCO UNITS/TRAIN
PSSNGR/FRGHT STTNS FILE     PSMLNBPN            8  PSSNGR CARS/TRAIN
LOCO CHARACTERISTICS FILE   MBNBPPLC
CAR CHARACTERISTICS FILE    MBNBPPCR          130  PASSENGERS/CAR


AVG LOADED CAR       127.500 LBS.          TRN WEIGHT     707.15 TONS


ORIGIN:  NEW BEDFORD                 DSTNTN:  ML-BRNCH JUNCTION



                PASSENGER                         CENTERLINE
                 STATION                           LOCATION
                ---------                         ----------

            NEW BEDFORD                              272+20
            EAST TAUNTON                            1185+83
            TAUNTON CENTER                          1301+97
            ML-BRNCH JUNCTION                       1868+64
```

```
                    TRAIN  PERFORMANCE


MBTA CMMTR RAIL. VHB ENGNRNG: SAB                              9504-101
PRLMNRY PSSNGR SRVC PRFRMNC NB              LOCOPRFM         14 AUG 95
MAIN LINE JUNCTION-NEW BEDFORD           VRSN 30 JUN 91            SGB


                      MAXIMUM                 AVERAGE             AVERAGE
                       SPEED     RUNNING      RUNNING    DWELL    INTRSTTN
    STATION           REACHED     TIME         SPEED     TIME      SPEED
------------------    -------   ---------     -------    -----    --------
                       (MPH)    (MIN:SEC)      (MPH)     (SEC)     (MPH)

NEW BEDFORD             0.0       0:00          0.0        0        0.0
EAST TAUNTON           60.0      21:57         47.2       60       45.2
TAUNTON CENTER         25.0       5:46         22.9       60       19.5
ML-BRNCH JUNCTION      60.2      16:20         39.4        0       39.4
                                -------                  -----
   TOTALS                        44:03                    120


         DEPARTURE-ARRIVAL TIME   =  46  MINUTES,  3  SECONDS

         TOTAL TRIP LENGTH        =  30.23  MILES
         AVG. COMMERCIAL SPEED    =  39.3   MPH
```

PRLMNRY PSSNGR SRVC PRFRMNC NB
MAIN LINE JUNCTION-NEW BEDFORD



SPEED/DISTANCE

CAR FILE: MBNBPPCR

CARS: 8

PASSENGERS/CAR: 130

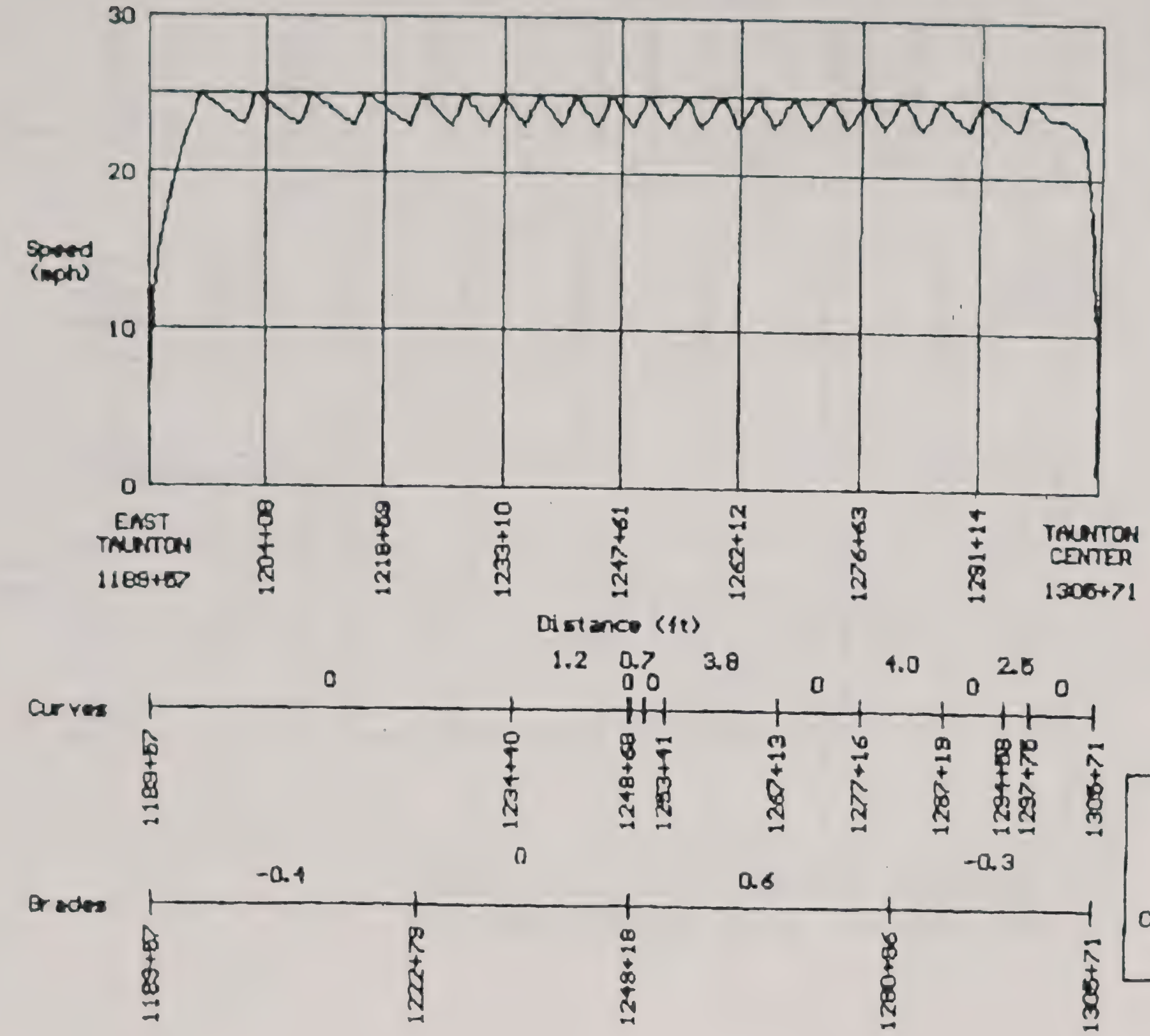
PROFILE: PFMLNBPN

—— SPEED LIMIT

KEYS

← BACKWARD
→ FORWARD
C TOGGLE COLOR/GRAY
Ctrl C DEFINE COLORS
Esc QUIT

PRLMNRY PSSNGR SRVC PRFRMNC NB
MAIN LINE JUNCTION-NEW BEDFORD



SPEED/DISTANCE

CAR FILE: MBNBPPCR

CARS: 8

PASSENGERS/CAR: 130

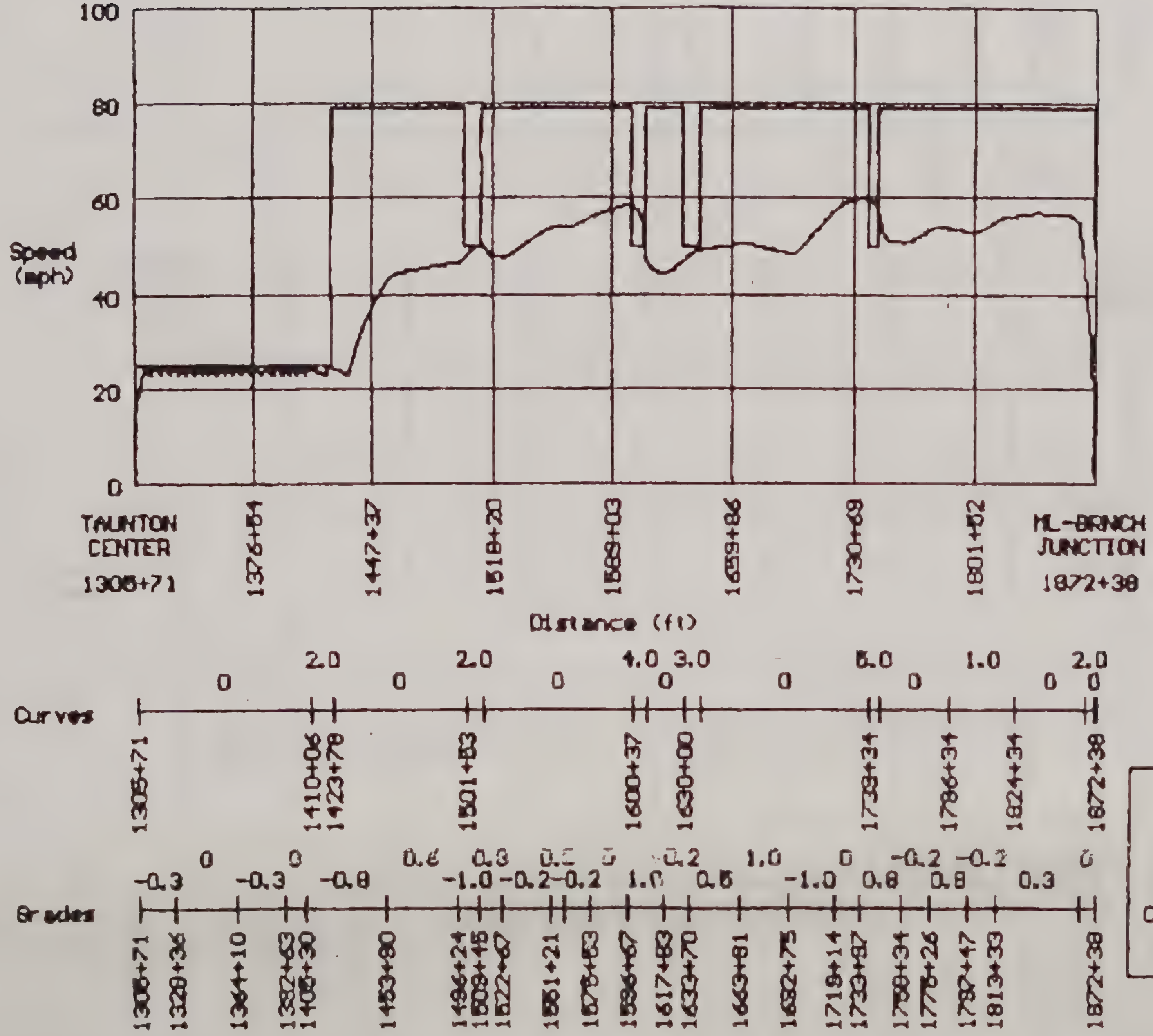
PROFILE: PFMLNBPN

—— SPEED LIMIT

KEYS

←	BACKWARD
→	FORWARD
C	TOGGLE COLOR/GRAY
Ctrl C	DEFINE COLORS
Esc	QUIT

PRLMNRY PSSNGR SRVC PRFRMNC NB
MAIN LINE JUNCTION-NEW BEDFORD



SPEED/DISTANCE

CAR FILE: MBNBPPCR

CARS: 8

PASSENGERS/CAR: 130

PROFILE: PFMLNBPH

—— SPEED LIMIT

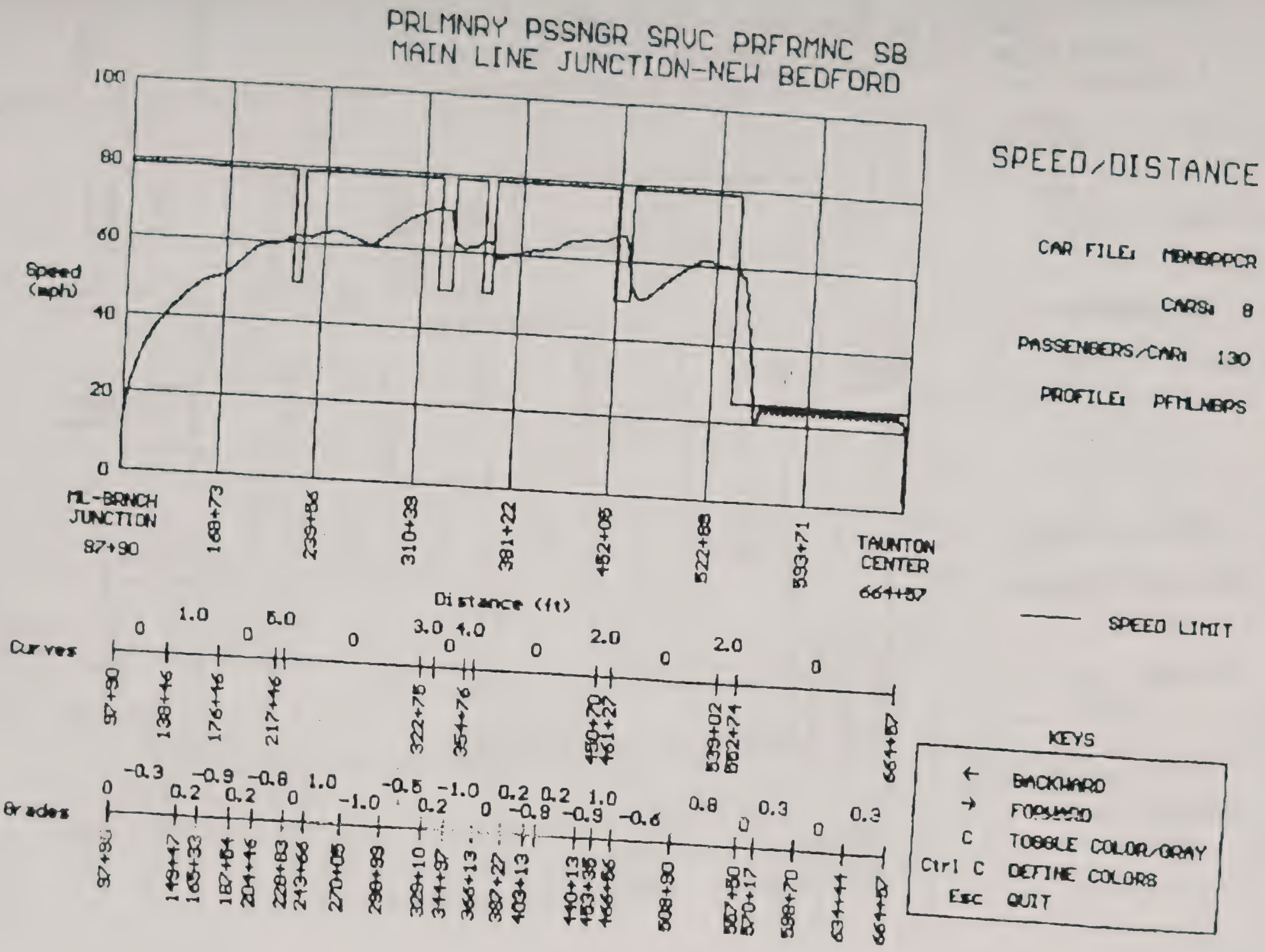
KEYS

← BACKWARD
→ FORWARD
C TOGGLE COLOR/GRAY
Ctrl C DEFINE COLORS
Esc QUIT

```
                 TRAIN  PERFORMANCE


MBTA CMMTR RAIL, VHB ENGNRNG: SAB                               9504 101
PRLMNRY PSSNGR SRVC PRFRMNC SB                    LOCOPRFM     14 AUG 95
MAIN LINE JUNCTION-NEW BEDFORD                 VRSN 30 JUN 91        SGB


PROFILE TABLE                 PFMLNBPS             1  LOCO UNITS/TRAIN
PSSNGR/FRGHT STTNS FILE       PSMLNBPS             8  PSSNGR CARS/TRAIN
LOCO CHARACTERISTICS FILE     MBNBPPLC
CAR CHARACTERISTICS FILE      MBNBPPCR           130  PASSENGERS/CAR


AVG LOADED CAR        127.500 LBS.          TRN WEIGHT      707.15 TONS


ORIGIN:  ML-BRNCH JUNCTION           DSTNTN:  NEW BEDFORD


              PASSENGER                               CENTERLINE
               STATION                                 LOCATION
              ---------                               ---------


          ML-BRNCH JUNCTION                                94+16
          TAUNTON CENTER                                  660+83
          EAST TAUNTON                                    776+97
          NEW BEDFORD                                    1690+60
```

TRAIN PERFORMANCE

```
MBTA CMMTR RAIL. VHB ENGNRNG: SAB                                 9504-101
PRLMNRY PSSNGR SRVC PRFRMNC SB                   LOCOPRFM       14 AUG 95
MAIN LINE JUNCTION-NEW BEDFORD                VRSN 30 JUN 91          SGB

                     MAXIMUM                 AVERAGE              AVERAGE
                      SPEED     RUNNING      RUNNING     DWELL    INTRSTTN
    STATION          REACHED     TIME         SPEED      TIME      SPEED
---------------      -------   ---------     -------     -----   ---------
                      (MPH)    (MIN:SEC)      (MPH)      (SEC)     (MPH)

ML-BRNCH JUNCTION      0.0       0:00          0.0         0        0.0
TAUNTON CENTER        71.2      14:53         43.2        60       40.5
EAST TAUNTON          25.0       5:46         22.8        60       19.4
NEW BEDFORD           78.4      20:54         49.6         0       49.6
                               ------                    -----
   TOTALS                       41:33                     120


          DEPARTURE-ARRIVAL TIME    :  43  MINUTES.  33  SECONDS

          TOTAL TRIP LENGTH         =  30.23  MILES
          AVG. COMMERCIAL SPEED     =  41.6   MPH
```



PRLMNRY PSSNGR SRVC PRFRMNC SB
MAIN LINE JUNCTION-NEW BEDFORD

SPEED/DISTANCE

CAR FILE: MBNBPPCR

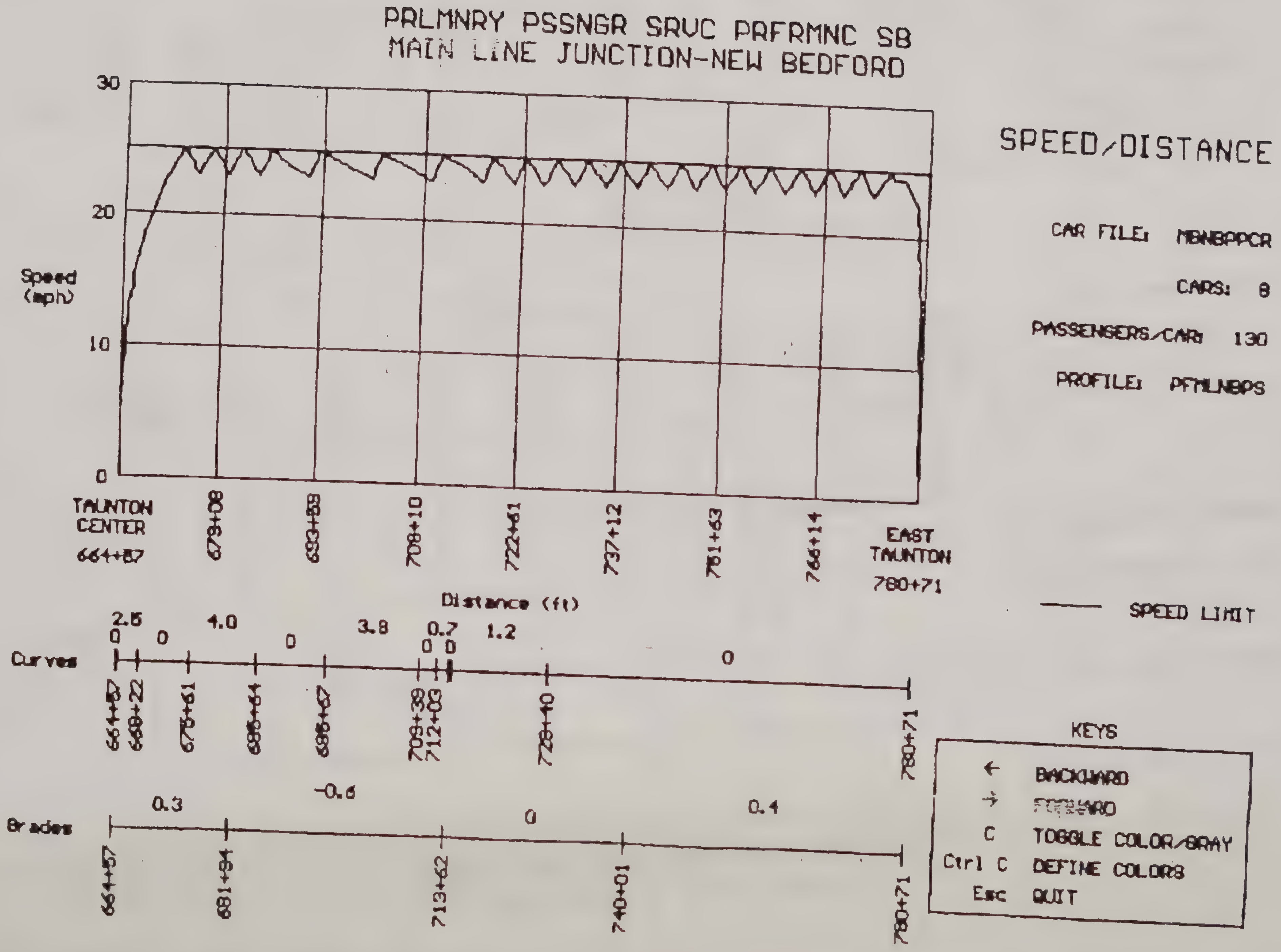
CARS: 8

PASSENGERS/CAR: 130

PROFILE: PFMLNBPS

KEYS

← BACKWARD
→ FORWARD
C TOGGLE COLOR/GRAY
Ctrl C DEFINE COLORS
Esc QUIT



SPEED/DISTANCE

CAR FILE: MBNBPPCR

CARS: 8

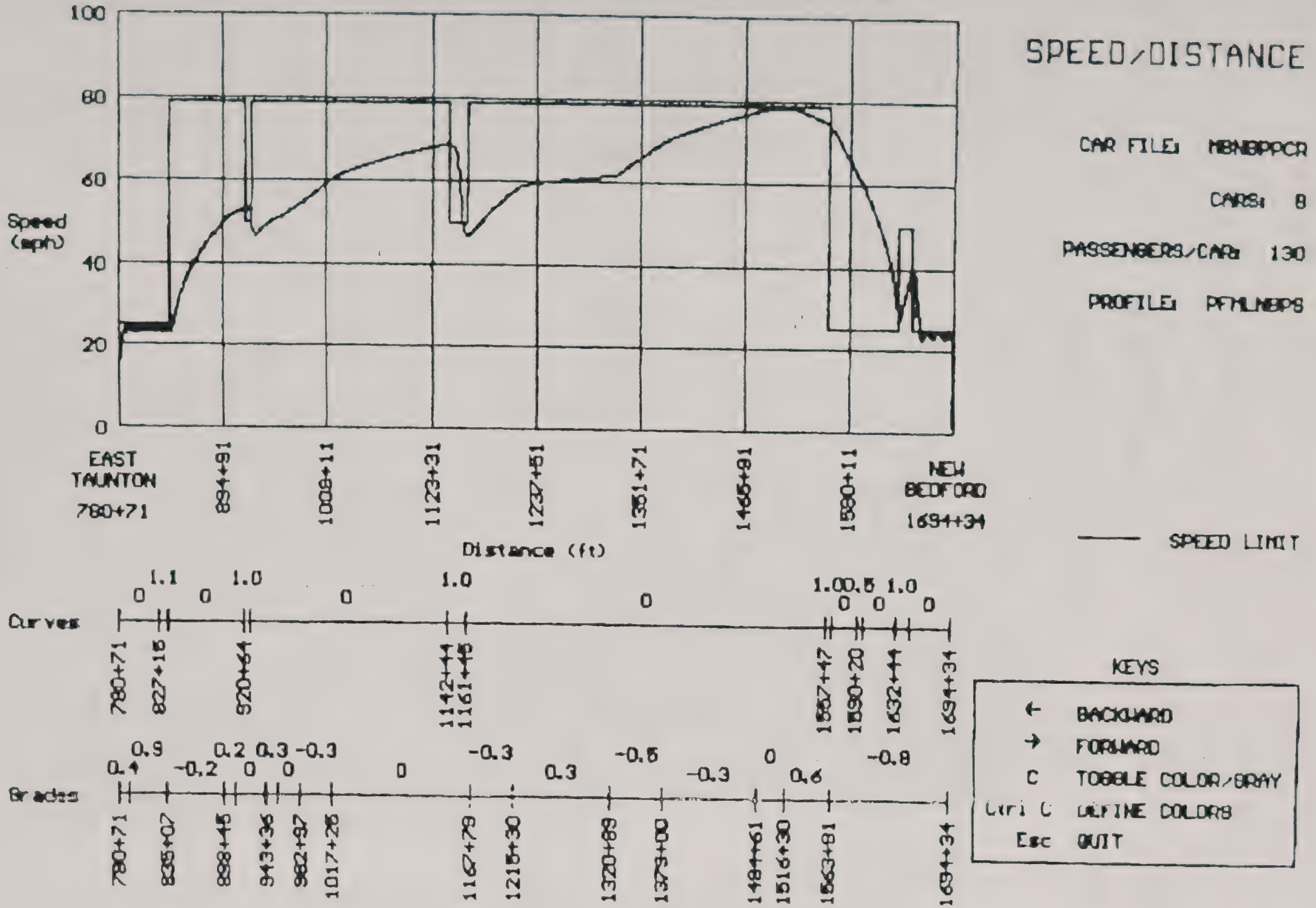
PASSENGERS/CAR: 130

PROFILE: PFMLNBPS

KEYS

← BACKWARD
→ FORWARD
C TOGGLE COLOR/GRAY
Ctrl C DEFINE COLORS
Esc QUIT

PRLMNRY PSSNGR SRVC PRFRMNC SB
MAIN LINE JUNCTION-NEW BEDFORD



SPEED/DISTANCE

CAR FILE: MBNBPPCR

CARS: 8

PASSENGERS/CAR: 130

PROFILE: PFMLNBPS

DL LOCO CHARACTERISTICS DATA FILE

```
DATA FILE NAME: MSNBPPLC              CRCHMGMT                07 AUG 95
OPERATOR INILS: SGB               VRSN 30 AUG 90               PAGE  1

EQUIPMENT TYPE IS:     DIESEL-POWERED LOCOMOTIVE


L5( 1)    STANDING WEIGHT, TONS                                 197.00000
L5( 2)    NUMBER OF SEATS                                         4.00000
L5( 3)    NUMBER OF AXLES                                         6.00000
L5( 4)    LOCO LENGTH OVER COUPLERS, FEET                        67.25000
L5( 5)    LOCO FRONTAL AREA, SQUARE FEET                        142.00000
L5( 6)    FLANGE RESISTANCE COEFFICIENT                           0.03000
L5( 7)    AIR DRAG RESISTANCE COEFF, LEAD UNIT                    0.00270
L5( 8)    AIR DRAG RESISTANCE COEFF, TRLG UNIT                    0.00060
L5( 9)    JERK RATE LIMIT, MPHPSPS                                3.00000
L5(10)    ACCELERATION WHEEL-SLIP AVG EFFICIENCY, %              85.00000
L5(11)    BRAKING WHEEL-SLIDE AVG EFFICIENCY, %                  80.00000
L5(12)    LOCO BODY TRUCK CENTERS DISTANCE, FEET                 37.25000
L5(13)    TRUCK CENTERS BENEATH COUPLERS, FEET                   30.00000
L5(14)    TRUCK WHEELBASE BETWEEN AXLES, FEET                     8.00000
L5(15)    AUXIL POWER DRAWN FROM PRPLSN PWR-TRN, HP              18.00000
L5(16)    AUXIL POWER PROPULSION CUT-OFF SPEED, MPH              12.00000
L5(17)    AUXIL POWER CURRENT DRAWN FROM WYSD, AMPS            (NO VALUE)
L5(18)    ON-BOARD ELECTRICAL ENERGY LOSSES, %                    4.00000
L5(19)    ON-BOARD MECHANICAL FRICTION LOSSES, %                  7.00000
L5(20)    LOCO ROTATIONAL WEIGHT AS % OF TARE, %                  8.00000
L5(21)    POWER DISTRIBUTION LOSSES, %                         (NO VALUE)
L5(22)    POWER CONVERSION LOSSES, %                           (NO VALUE)
L5(23)    MOTOR 1-HR CURRENT RATING, AMPS                      (NO VALUE)
L5(24)    PERCENT NORMAL VENTILATION IN STATIONS, %            (NO VALUE)
L5(25)    NUMBER OF TRUCKS SUPPORTING THE UNIT                    2.00000
P5( 1)    FULL (1.0) OR HALF (0.5) POWER SETTING                  1.00000
P5( 2)    NUMBER OF POWERED AXLES PER LOCO                        6.00000
P5( 3)    NUMBER OF POWERED AXLES PER MOTOR                    (NO VALUE)
P5( 4)    INSTALLED WHEELS DIAMETER, INCHES                      40.00000
P5( 5)    INSTALLED GEAR RATIO, DECIMAL FRACTION                  3.52940
P5( 6)    DIESEL ENGINE HORSEPOWER RATING, HP                 3,400.00000
P5( 7)    DIESEL ENGINE OUTPUT EFFICIENCY, %                     85.00000
P5( 8)    GOVERNOR MAXIMUM SPEED (IF PRESENT), MPH                0.00000
B5( 1)    OVERSPEED DETECTION INTERVAL, SEC                       2.00000
B5( 2)    BRAKING SIGNAL RECOGNITION TIME, SEC                    2.50000
B5( 3)    BRAKING TRANSITION DEAD INTERVAL, SEC                   0.50000
B5( 4)    BRAKING RATE APPLICATION TIME, SEC                      0.80000
B5( 5)    BRAKING RATE PROPAGATION, SEC PER CAR                   0.15000
B5( 6)    ROCD SPEED LIMIT PENETRATION MARGIN, MPH                2.00000
B5( 7)    THRESHOLD SPEED TO SMALLER MARGIN, MPH                 15.00000
B5( 8)    SMALLER SPEED LMT PENETRATION MARGIN, MPH               1.00000
B5( 9)    SHOE-WHEEL FRICTION DEGREE OF CURVE                     5.00000
B5(10)    NUMBER OF BRAKE CYLINDERS PER LOCO                     12.00000
B5(11)    NUMBER OF WHEELS BRAKED PER CYLINDER                    1.00000
B5(12)    NOMINAL BRAKING RATIO AT BWO STNDNG WGHT                0.48000
B5(13)    BRAKE PIPE CONTROL PRESSURE AT BWO, PSI                70.00000
```

```
DL LOCO CHARACTERISTICS DATA FILE

DATA FILE NAME: MBNBPPLC                 CRCHMGMT              07 AUG 95
OPERATOR INTLS: SGB                  VRSN 30 AUG 90             PAGE  2

EQUIPMENT TYPE IS:     DIESEL-POWERED LOCOMOTIVE


B5(14)    BWO FULL-SRVC EQUALIZING REDUCTION, PSI               23.00000
B5(15)    BRAKE CYLINDER CRSS-SCTNL AREA, SQ-IN                 63.62000
B5(16)    BRAKE CYLINDER PISTON TRAVEL LENGTH, IN               10.00000
B5(17)    BRAKE RIGGING LEVERAGE RATIO, DCML                     5.65000
B5(18)    CYLINDER AND RIGGING EFFICIENCY, %                    82.00000
B5(19)    MAXMM FRICTION COEFF, SHOE/WHL-TREAD, %               46.00000
B5(20)    MINMM FRICTION COEFF, SHOE/WHL-TREAD, %               28.00000
B5(21)    CUT-OFF SPEED FOR FRICTION CURVE, MPH                  1.00000
B5(22)    MAXMM CONTINUOUS WHEEL BRK-HRSPWR, HP                 40.00000


CURVEFIT FILE NAME: ARSFCOMO       CORRELATION COEFFICIENT:  .99994


FILE CREATED: 27 JUL 95 , GRB          LAST REVISED: 27 JUL 93 , GRB
    DSCRPTN: NJEL LCMTV, 1976; GE MNFCTR: 3400 HP DSL/DC ENGINE
    REMARKS: ELCTRC TRCTN MTR DRIVE; DYN BRK: TO TEST LC PRF&SP
CLIENT: MASS BAY TRANSPORTATION AUTHORITY          CNTRCT: 9405-102
```

CAR CHARACTERISTICS DATA FILE

```
DATA FILE NAME: MBNBPPCR              CRCHMGMT                07 AUG 95
OPERATOR INTLS: SGB                VRSN 30 AUG 90             PAGE  1

EQUIPMENT TYPE IS:     UNPOWERED PASSENGER COACH OR FREIGHT CAR


C5( 1)    EMPTY WO WEIGHT, TONS                                54.00000
C5( 2)    NUMBER OF SEATS                                     130.00000
C5( 3)    NUMBER OF AXLES                                       4.00000
C5( 4)    CAR LENGTH OVER COUPLERS, FEET                       85.00000
C5( 5)    CAR FRONTAL AREA, SQUARE FEET                       140.00000
C5( 6)    FLANGE RESISTANCE COEFFICIENT                         0.03500
C5( 7)    AIR DRAG RESISTANCE COEFF, LEAD CAR                   0.00240
C5( 8)    AIR DRAG RESISTANCE COEFF, TRLG CAR                   0.00034
C5( 9)    JERK RATE LIMIT, MPHPSPS                              2.40000
C5(10)    ACCELERATION WHEEL-SLIP AVG EFFICIENCY, %            85.00000
C5(11)    BRAKING WHEEL-SLIDE AVG EFFICIENCY, %                80.00000
C5(12)    CAR BODY TRUCK CENTERS DISTANCE, FEET                59.50000
C5(13)    TRUCK CENTERS BENEATH COUPLERS, FEET                 25.50000
C5(14)    TRUCK WHEELBASE BETWEEN AXLES, FEET                   8.50000
C5(15)    AUXIL POWER DRAWN FROM PRPLSN PWR-TRN, HP            78.00000
C5(16)    AUXIL POWER PROPULSION CUT-OFF SPEED, MPH            12.00000
C5(17)    AUXIL POWER CURRENT DRAWN FROM WYSD, AMPS          (NO VALUE)
C5(18)    CAR-BORNE ELECTRICAL ENERGY LOSSES, %              (NO VALUE)
C5(19)    CAR-BORNE MECHANICAL FRICTION LOSSES, %               7.00000
C5(20)    CAR ROTATIONAL WEIGHT AS % OF TARE, %                 8.00000
C5(21)    POWER DISTRIBUTION LOSSES, %                       (NO VALUE)
C5(22)    POWER CONVERSION LOSSES, %                         (NO VALUE)
C5(23)    MOTOR 1-HR CURRENT RATING, AMPS                    (NO VALUE)
C5(24)    PERCENT NORMAL VENTILATION IN STATIONS, %          (NO VALUE)
C5(25)    NUMBER OF TRUCKS SUPPORTING THE CAR                   2.00000
C5(26)    UNPOWERED CARS SRVC COMMITMENT WOULD BE:                PSSGR
P5( 1)    INSTALLED WHEELS DIAMETER, INCHES                    36.00000
P5( 2)    LOAD-WEIGHING MXMM W2 LOAD, LADING TONS               9.80000
B5( 1)    OVERSPEED DETECTION INTERVAL, SEC                     2.50000
B5( 2)    BRAKING SIGNAL RLCOGNITION TIME, SEC                  2.50000
B5( 3)    BRAKING TRANSITION DEAD INTERVAL, SEC                 0.80000
B5( 4)    BRAKING RATE APPLICATION TIME, SEC                    1.20000
B5( 5)    BRAKING RATE PROPAGATION, SEC PER CAR                 0.20000
B5( 6)    RDCD SPEED LIMIT PENETRATION MARGIN, MPH              2.00000
B5( 7)    THRESHOLD SPEED TO SMALLER MARGIN, MPH               10.00000
B5( 8)    SMALLER SPEED LMT PENETRATION MARGIN, MPH             0.80000
B5( 9)    SHOE-WHEEL FRICTION DEGREE OF CURVE                   6.00000
B5(10)    NUMBER OF BRAKE CYLINDERS PER CAR                     4.00000
B5(11)    NUMBER OF WHEELS BRAKED PER CYLINDER                  2.00000
B5(12)    NOMINAL BRAKING RATIO AT BWO TARE                     0.46000
B5(13)    BRAKE PIPE CONTROL PRESSURE AT BWO, PSI              70.00000
B5(14)    BWO FULL-SRVC EQUALIZING REDUCTION, PSI              23.00000
B5(15)    BRAKE CYLINDER CRSS-SCTNL AREA, SQ-IN                78.54000
B5(16)    BRAKE CYLINDER PISTON TRAVEL LENGTH, IN               8.00000
B5(17)    BRAKE RIGGING LEVFRAGE RATIO, DCML                    5.13000
B5(18)    CYLINDER AND RIGGING EFFICIENCY, %                   54.00000
```

Middleborough Line Operations Simulation February 1997

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

NEW BEDFORD/FALL RIVER COMMUTER RAIL EXTENSION PROJECT

TASK 3 TECHNICAL MEMORANDUM

MIDDLEBORO LINE OPERATIONS SIMULATION

Prepared by:

LS TRANSIT SYSTEMS, INC.

Submitted to:

Vanasse, Hangen Brustlin, Inc.

February, 1997

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

NEW BEDFORD/FALL RIVER COMMUTER RAIL EXTENSION PROJECT

TASK 3

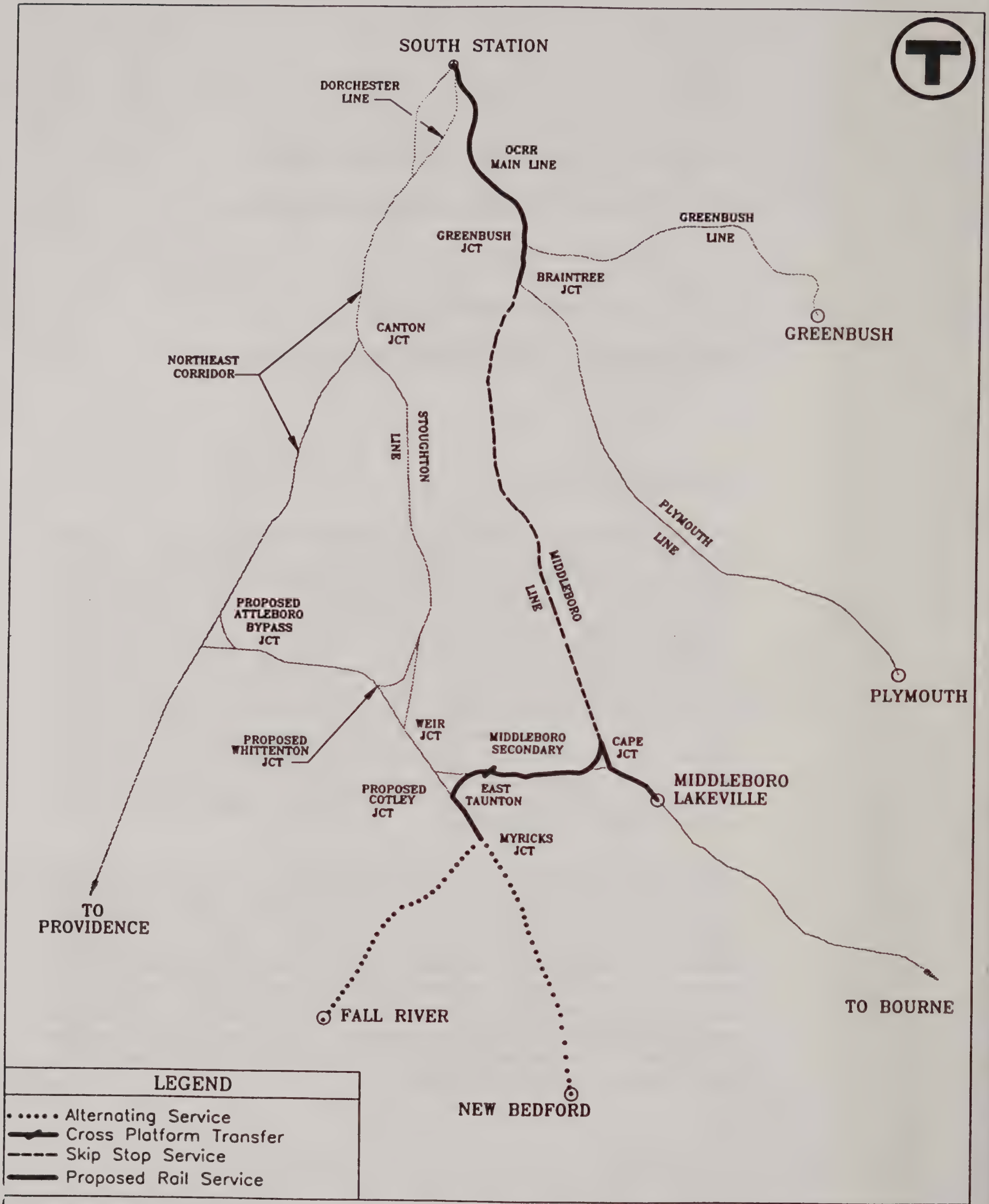
TECHNICAL MEMORANDUM

OPERATIONS SIMULATION OF THE MIDDLEBORO LINE

1.0 PROJECT OVERVIEW

The focus of this technical memorandum is the operational analysis of the feasibility and implications of extending commuter rail service to New Bedford and Fall River via the Middleboro Branch of the MBTA Old Colony Line. This route is presently being reconstructed to permit service to be reestablished that had been discontinued several decades ago. The study proposes to accomplish the New Bedford/Fall River extension by operating additional trains via the Old Colony Main Line segment between South Station, Boston and Braintree; and continue south on the Middleboro Line to just short of the branch endpoint at Middleboro-Lakeville Station. Beyond that point, trains would continue west on the Conrail Middleboro Secondary for eight miles to connect to Conrail's New Bedford Secondary at Cotley Junction just south of Taunton. The terminal stations of Fall River and New Bedford are each located on separate branch lines of the New Bedford Secondary which diverge from each other at Myricks Junction, 3.5 miles south of Cotley Junction. Figure 1 displays the rail corridor simulated for the study area.

The goal of the study was to determine the feasibility of achieving the level of service of 60 trains per day (with 15 minute peak intervals and 30 minute off-peak intervals, in each direction) to New Bedford/Fall River being served by alternating standard consists and/or combined Diesel Multiple Units (DMUs). An operations simulation model was developed using RAILSIM®, LSTS's PC-based rail operations simulation software. The model incorporated the track and signal system, and rail equipment expected to be in place by the Year 2010 on the Old Colony Line. The simulation of the extension to New Bedford and Fall River applied a basic track plan and a rudimentary signal system for the purpose of this study. This report details the assumptions, methodologies and results of this analysis.



LSTS LS Transit Systems

NEW BEDFORD\FALL RIVER COMMUTER RAIL EXTENSION PROJECT
CROSS PLATFORM TRANSFER AT EAST TAUNTON
SKIP STOP SERVICE ON MIDDLEBORO LINE

FIGURE 1

FEBRUARY 5,19

2.0 ASSUMPTIONS

For the development of the Middleboro Line alternative simulation, the following assumptions were included:

2.1 TRACK AND SIGNAL IMPROVEMENTS OF OLD COLONY MAIN LINE AND MIDDLEBORO LINE

Elements of the track alignment plan for the Old Colony route used for this study (the Old Colony Main Line and the Middleboro Line) were those that will be in place for opening of service in 1997. Longer-range plans by the MBTA to double-track most of the Middleboro Line (Braintree to Bridgewater) were not included in the simulation. Possible enhancements to the Main Line also were not taken into account. The signal system governing train movements input to the simulation's database was that of the cab signal system recently designed for installation on the Old Colony Line.

2.2 TRACK AND SIGNAL IMPROVEMENTS BEYOND MIDDLEBORO

The Conrail-owned rail lines beyond Middleboro that would be used for this alternative are presently single-track with a low maximum speed of 40 mph, and in some sections as low as 10 mph, which is not conducive to establishing a successful rail passenger service. The signal system simulated was only a rudimentary one in order to satisfy the model. The simulation's database was coded with characteristics similar to those being installed for the reconstruction of Old Colony service. This means generally 70 mph speeds, with some 40 mph stretches through interlockings and built-up urban centers.

2.3 ADDITIONAL STATIONS ALONG THE OLD COLONY MAIN LINE

The simulation includes all stations along the Middleboro Line that were originally programmed for the start-up of Old Colony service. It also includes the Braintree Station at the south end of the Old Colony Main Line segment. Two additional stations along the Main Line which were recently added to the route by the MBTA were also part of this simulation: the station at Quincy Center and the station near Columbia Point serving UMass/Boston. Because the service functions of these stations was not fully evolved in the first draft of MBTA schedules, the simulation development process was used to better define a role for these stations to play in the context of both the Old Colony 2010 service plan and the possible routing of New Bedford/Fall River service via Middleboro.

2.4 YEAR 2010 MBTA SERVICE SCHEDULES FOR OLD COLONY LINES

Because the Old Colony Lines are not yet in service, no existing railroad operation can be used as a base for planning additions to operations on the substantially single-track route. Although some draft schedules for Old Colony were provided by the MBTA, they either omitted some branches or some recently added stations, or they contained a railroad operating pattern that the simulation found to be unworkable. As a first step in building the simulation, a full 2010 Old Colony schedule was built containing all three branches and the additional stations. After a working timetable was built, NB/FR trains were then added to the maximum extent possible.

2.5 RAIL OPERATIONS ACROSS THE FORT POINT CHANNEL BRIDGE EXTENDING TO SOUTH STATION

A critical track segment affecting all operations on the Old Colony Line is the railroad bridge over the Fort Point Channel, located immediately south of South Station. The bridge presently handles the Dorchester Line and will be used by all trains on the Old Colony Lines. In addition, all train consists moving between the South Station platform tracks and all daily scheduled maintenance in the coach yard must pass over the bridge. Included in the simulation is the permanent four-track bridge over the Channel programmed for completion by 2010. *Specific movements to and from the coach yard were not included in the simulation.* Currents of operating rail traffic were established on the four tracks of the bridge at different times of day; reflecting the prevailing direction of yard moves that accommodate revenue trains during the same times. In addition, Old Colony revenue trains in the preliminary simulation were routed into South Station to determine the feasibility of using only two platform tracks.

3.0 SIMULATION METHODOLOGY

3.1 SOURCES OF SIMULATION DATA

The following source documents were utilized to develop and refine the RAILSIM® simulation models. This list is not all-inclusive; additional sources, including input from the MBTA and consulting firms, contributed information and advice to the models. Examples of this type of information include construction of Tracks 12 and 13 at South Station and the accompanying changes to the Tower 1 interlocking and to the Fort Point Channel Bridge. Official sources of documents include:

- Old Colony Railroad Rehabilitation Project: Track charts for Main Line and Middleboro Line
- Draft Old Colony schedules developed in 1996 and circa 1992 were provided by the MBTA
- ABB Corporation, "IC3 Performance Data", with acceleration and braking curves, circa December 1993
- U.S. Geological Survey 1:25,000-scale metric topographic maps for Brockton, Taunton, and Somerset Mass.
- Cab signal control lines for the Old Colony Main Line and Middleboro Line provided by VHB
- Track charts provided by VHB for the existing New Bedford Secondary, Middleboro Secondary, and the Fall River Branch
- New Bedford/Fall River Commuter Rail Project Report; VHB, September 11, 1995

3.2 DEVELOPMENT OF MIDDLEBORO ALTERNATIVE SIMULATION MODEL

Train operations for the Middleboro alternative simulation presented a particular challenge, requiring LSTS to first develop a new Old Colony rail service plan. This was necessary because the Old Colony is not yet in operation. The following service types for New Bedford/Fall River service were studied for the simulation:

3.2.1 Tandem Express Service (Conventional Consists Along the Middleboro Line)

This option will have push/pull diesel locomotives and coaches of the same type used by the MBTA today operating between downtown Boston and Myricks Junction. Alternate trains will operate to and from Fall River and New Bedford. An alternative option allows for the remote endpoint not served by a through train to have a shuttle connection to the proposed East Taunton station for passengers to make a cross-platform transfer.

During peak periods, NB/FR trains operating between Boston and the outlying terminals would stop at every other station along the Middleboro Line, including Bridgewater, Brockton, and Holbrook-Randolph; plus Quincy Center. Tandem express service is particularly useful on rail lines with closely spaced stations (as the Middleboro Line has through Brockton) and/or has its busiest station close-in (Holbrook/Randolph has the highest ridership projection on the branch). Another train originating or terminating at Middleboro in the same South Station arrival or departure time slot would serve all remaining stops between Middleboro/Lakeville and Boston, namely Campello and Montello, plus Braintree. During off-peak, all trains to NB/FR or to Middleboro/Lakeville would make all stops along their route.

3.2.2 Tandem Express Service (DMU Consists from Both Outlying Terminals Joining at East Taunton)

This option will have Diesel Multiple Unit (DMU) trains operating between downtown Boston and Fall River and New Bedford. Trains from both remote terminals would couple together inbound to Boston and would separate outbound at the proposed East Taunton station. This will allow each endpoint to have through service in each time slot and eliminate the need for passengers to make a cross-platform transfer.

During peak periods, the combined DMU trains operating between Boston and the outlying terminals would stop at every other station along the Middleboro Line, including Bridgewater, Brockton, and Holbrook-Randolph; plus Quincy Center. Another train originating or terminating at Middleboro/Lakeville in the same South Station arrival or departure time slot would serve all remaining stops between Middleboro/Lakeville and Boston, namely Campello and Montello, plus Braintree. During off-peak, all trains to NB/FR or to Middleboro/Lakeville would make all stops along their route.

3.3 PERFORMANCE EVALUATION METHODOLOGY

The NB/FR trains were examined for their delay impact on base services. The on-time performance at key stations was then computed. The key stations were: South Station in the inbound direction, and Quincy or Braintree in the outbound direction. Summary tables of on-time performance were generated for each measurement site for the 6:00 AM to 9:00 AM morning peak and the 4:00 PM to 7:00 PM evening peak. In addition to lateness statistics at these stations, signal delay minutes were calculated for the evening peak. A signal delay minute is accrued when a train is slowed or stopped by signal indication and/or cab signal code for one minute. A signal delay minute does not necessarily represent actual train delay; it indicates that a train was operating on less than clear signals for the specified period of time

After collecting signal delay totals for the full schedule, the NB/FR trains were eliminated. Without making any other changes, the simulation was run again to compute signal delay minutes without the NB/FR trains. This generates a delta that can be attributed entirely to the addition of NB/FR trains and gives an indication of the "stress" on system capacity due to these additions. Signal delays are a reliable indication of delays caused by conflicting traffic. A perfectly designed and executed operating plan with consistent headways and no conflicts at interlockings (such as junctions) would exhibit zero signal delay minutes.

An analysis of simulated delays was performed on each model with full train services to evaluate the stability of the schedule under realistic conditions. Delay simulation mimics real-world terminal departure and intermediate dwell delays. Large changes in on-time performance and signal delay minutes indicate a fragile operational plan that would potentially have difficulty overcoming minor changes. On-time performance at stations is another way to measure the impact of random delays.

4.0 OPERATING AND DESIGN ISSUES

Numerous ancillary issues and concerns were addressed at the outset of the project or became apparent during the development of the simulation models. Many are related to how railroad service between New Bedford or Fall River and Boston will be operated in the future. The ramifications of decisions already made by design or by default will be considered fixed constraints. Each of the major items so identified is discussed in the subsections that follow. Design parameters were established as a part of Task 1 of this project. Refer to the Task 1 Service Plan Matrices deliverable for more information.

4.1 OPERATIONS AND CAPACITY AT SOUTH STATION

It is acknowledged that the capacity of South Station and its support facilities will be increasingly taxed in the near future. However, analysis for the entire South Station terminal plant was not done as part of this project. The preliminary simulation for the three-branch Old Colony route was developed with a fixed number of consists, and was carried into South Station to determine the possibility of those trains using only two platform tracks.

The simulation that adds New Bedford/Fall River trains to the Old Colony was primarily concerned with attaining the greatest number of trains. The capacity of the Old Colony Main Line, with several segments of single track, was the determining element in the maximizing of the number of trains. Operations in the terminal plant were not evaluated, except that the four tracks on the Fort Point Channel Bridge programmed for completion by 2010 had their usage optimized to take into account train movements between the coach yard and the South Station platform tracks.

4.2 TIMETABLE DEVELOPMENT ON THE OLD COLONY LINES

In addition to possibly serving as the route into Boston for New Bedford/Fall River trains, the Old Colony Main Line is presently being reconstructed to accommodate a three-branch MBTA commuter rail operation programmed for start-up in the next few years. These branches will diverge from the Main Line in Braintree enroute to Middleboro (the alignment under consideration for New Bedford/Fall River service), to Plymouth, and in the future to Greenbush station in Scituate.

The alignment of the Old Colony Main Line between Braintree and South Station has several segments of single-track. This is the result of the narrow right-of-way being shared by the Braintree Branch of the MBTA Red Line rapid transit. The ability to double-track the Main Line requires capital outlays at the different locations, with some sections not readily able to be altered at all because of physical constraints. In addition, all of the Old Colony branches are to be built as single-track with passing sidings, though there are long-range plans for double-tracking most of the branch mileage at a later date. The single-track character of the Old Colony lines makes schedule development difficult.

4.3 PROVIDING SERVICE HEADWAYS TO OUTLYING TERMINALS

The MBTA's stated goal is to provide 30 minute peak period, peak direction service to Fall River and to New Bedford, each of which is the terminus of a separate branch line. This results in the service headway of New Bedford/Fall River trains on the Old Colony segment being half the branch headway. The layout of the Old Colony Main Line, with its substantial segments of single-track, has sharply constrained capacity. In order to provide the maximum level of service and still offer a one-seat ride to and from Boston dictates that the service be configured one of three ways (or a combination):

- Alternating successive trains beyond East Taunton to the outlying terminals,
- DMU consists from each endpoint are joined inbound and separated outbound at East Taunton,
- Cross-platform transfers will be made at East Taunton for passengers traveling to or from branch line stations not served by a through train.

The latter option need not dictate that patrons on the Fall River Branch or the New Bedford Branch would exclusively get one-seat service. The pattern could alternate or be designed to reflect demand.

4.4 EQUIPMENT LAYOVER AND BALANCING

Equipment layover and balancing was not taken into account in this simulation. This would involve timetable refinement which is beyond the scope of the study. However, an attempt was made to develop New Bedford/Fall River service patterns which included approximately the same number of trips in each direction.

Because a fixed number of consists were involved (four per branch), the preliminary three-branch Old Colony schedule for 2010 did include equipment balancing. This preliminary simulation acted as a "Base Case" to which New Bedford/Fall River trains were added to determine the maximum possible operation, without the restriction of manipulating a fixed number of consists.

4.5 TRACK LAYOUT OF MIDDLEBORO LINE EXTENSION AND NB/FR BRANCHES

With the goal of this study being to maximize the number of trains, the principal factor driving schedule making was successfully inserting trains during peak periods onto the single-track Old Colony Main Line. No endeavor was made to devise a track layout plan for an extension to Fall River and New Bedford beyond Middleboro. The Conrail line west and south of Middleboro has had only a light volume of freight operations for several decades and is entirely single track.

Following a decision to route NB/FR service via a particular alternative, a further detailed study should be undertaken to refine a track alignment plan that takes into account the proposed schedule, the right-of-way width, and the optimal expenditure of public resources.

5.0 RESULTS

The simulation was prepared operating one reverse peak train on each Old Colony Branch. The result of the simulation was that 14 NB/FR trains could be supported on the Middleboro Line between 6:00 AM and 8:00 PM; with no reverse peak service to New Bedford and Fall River. Between 8:00 PM and 11:00 PM, it is assumed that two-hour headways will be operated inbound and outbound, resulting in a total of 18 trains per day.

A less desirable alternative was explored, that without reverse peak service. This simulation resulted in 16 New Bedford/Fall River (NB/FR) trains implemented between 6:00 AM and 8:00 PM each weekday. After 8:00 PM, it is assumed that two-hour headways will be operated inbound and outbound between 8:00 PM and 11:00 PM, resulting in a total of 20 trains per day.

The single-track Old Colony (with three other services using the Main Line) is the reason for the fewer trains. There are additional disadvantages to the operation on this alignment. The initial timetable developed for the simulation used all of the track space on the Main Line, preventing the scheduling of any reverse peak service; including morning trains to Bridgewater State College. The complete lack of reverse-peak service will require an additional consist be assigned to each Old Colony branch and to the NB/FR route itself; resulting in more locomotives cars and crews providing less service. The inability to recycle trainsets results in just a single assignment for each consist per peak period and more congestion on the Fort Point Channel Bridge and in the South Side coach yard.

Overloading the Old Colony Main Line and Middleboro Line with NB/FR service would prevent any service expansion on all of the routes using the Old Colony Line, as well as impact proposed future train service to Bourne or Cape Cod.

Estimated running time for conventional consists between both outlying terminals and South Station is 1 hour 17 minutes for tandem express trains and 1 hour 22 minutes for off-peak locals. The joining DMUs alternative increases running time to 1 hour 29 minutes for tandem express trains and 1 hour 34 minutes for off-peak locals.

5.1 OLD COLONY SCHEDULE DEVELOPMENT

Prior to the New Bedford/Fall River model development, a preliminary three-branch simulation was constructed that identified several rail scheduling patterns required for the successful operation of trains on the Old Colony Main Line. This preliminary Old Colony simulation had a fixed number of train consists per branch (four) and had the additional task of attempting to use only two platform tracks in South Station. The result was half-hourly service in the peak direction, with two hour off-peak headways. The evolution of that schedule is summarized as follows:

- A seven-minute peak direction headway is required on the Main Line because of recently added stations and to allow trains to clear the South Station plant or occupy platform tracks. *A five-minute headway in draft MBTA schedules was attempted but was found to be unworkable.*

- A "current of traffic" was established by time of day on the Old Colony Lines, with trains of a designated direction holding the Main Line at meet points and having priority of movement. Trains running against the flow take the siding and wait for opposing moves to clear. This enables movement in both directions at all times, instead of the draft timetable's proposal to not schedule anything against the direction of the peak period. Under this process, twelve o'clock noon is the time of day for changing the prevailing flow of traffic; inbound trains having timetable authority before that hour and outbound trains afterwards. It should be noted that meets were scheduled seamlessly to the greatest extent possible, with both trains being kept in motion. Only a few meets involve a train stopping and waiting.

- The trains of two of the Old Colony branches were operated on a headway close to each other (a train scheduling tactic known as "fleeting"), with the third branch's trains juxtaposed either inversely within the peak period time slot or to the next hour during off-peak. This allows all Old Colony service to be operated into two platform tracks at South Station, and permits reverse peak service. For the three branch simulation, Greenbush and Middleboro were fleeted, while Plymouth ran opposite their times. The draft MBTA schedule's tactic of fleeting together all three Old Colony branches during peak periods virtually eliminates the ability to recycle trainsets. When New Bedford/Fall River was added in the final simulation, its trains were fleeted with those of Plymouth. It should be noted that in the peak hour of the simulation schedule, peak direction time slots abut each other at the seven-minute headway, preventing opposing movements for that time frame on the Main Line only.

- Stations recently added on the Main Line received optimized service. Quincy Center station was served by Greenbush trains in the preliminary simulation with New Bedford/Fall River also stopping there in the final model. Plymouth and Middleboro trains made their connection with the Red Line at Braintree Station. This permitted optimal use of the passing siding at Braintree Station and allowed the largest number of trains to be scheduled within the confines of the seven-minute headway and the fleeting of trains. At UMass/Boston station, all trains in the prevailing direction by time of day provide service, maximizing potential ridership at that location.

5.2 MIDDLEBORO ALTERNATIVE SERVICE DEVELOPMENT

The first step prior to construction of the alternative's schedule was development of the three-branch Old Colony timetable for use as a "Base Case" to which NB/FR trains were inserted later. The parameters mentioned in the previous section were used in building the timetable, including seven-minute peak-direction headways on the Main Line, establishing current of traffic for meets by time of day, "fleeting" of trains to space train movements in the South Station plant, and setting up a service pattern for stations recently added on the Main Line.

Following completion of the base schedule, NB/FR services were inserted around the Old Colony operations. During peak periods, NB/FR trains will work in coordination with Middleboro trains; the two routes providing "Tandem" express service. Each group of trains stop at every other station along the Middleboro Line. NB/FR trains also serve outlying stations along the extension: New Bedford, Fall River, Freetown, and East Taunton. Tandem express service is particularly useful on rail lines with closely spaced stations (as the Middleboro Line has through Brockton) and/or has its busiest station close-in (Holbrook/Randolph has the highest ridership projection on the branch). However, the operating plan for tandem express service, if not precisely operated, has some potential for becoming unstable. During off-peak, trains serve all stops between Boston and outlying terminals.

String line diagrams of the operating plan for the Old Colony Main Line were generated in order to identify available time slots during peak periods, with reverse peak service. Tables 1 and 2 on the following pages display the string chart, which a graph of train operations with stations and interlockings laid out in the proper sequence on the Y-axis and time of day on the X-axis. Train operations are depicted as diagonal lines, with faster schedules by a line drawn at a steep vertical angle, while trains stopping at stations produce a straight horizontal line. Intersecting lines denote train passings, meetings and overtakes.

MBTA NB/FR MIDDLEBORO ALTERNATIVE STUDY
OPERATIONS SIMULATION REPORT

OLD COLONY MAIN LINE
AM PEAK PERIOD

TABLE 1

LEGEND

- INBOUND TRACK – DOUBLE TRACK SEGMENTS
- OUTBOUND TRACK – DOUBLE TRACK SEGMENTS
- SINGLE TRACK SEGMENTS

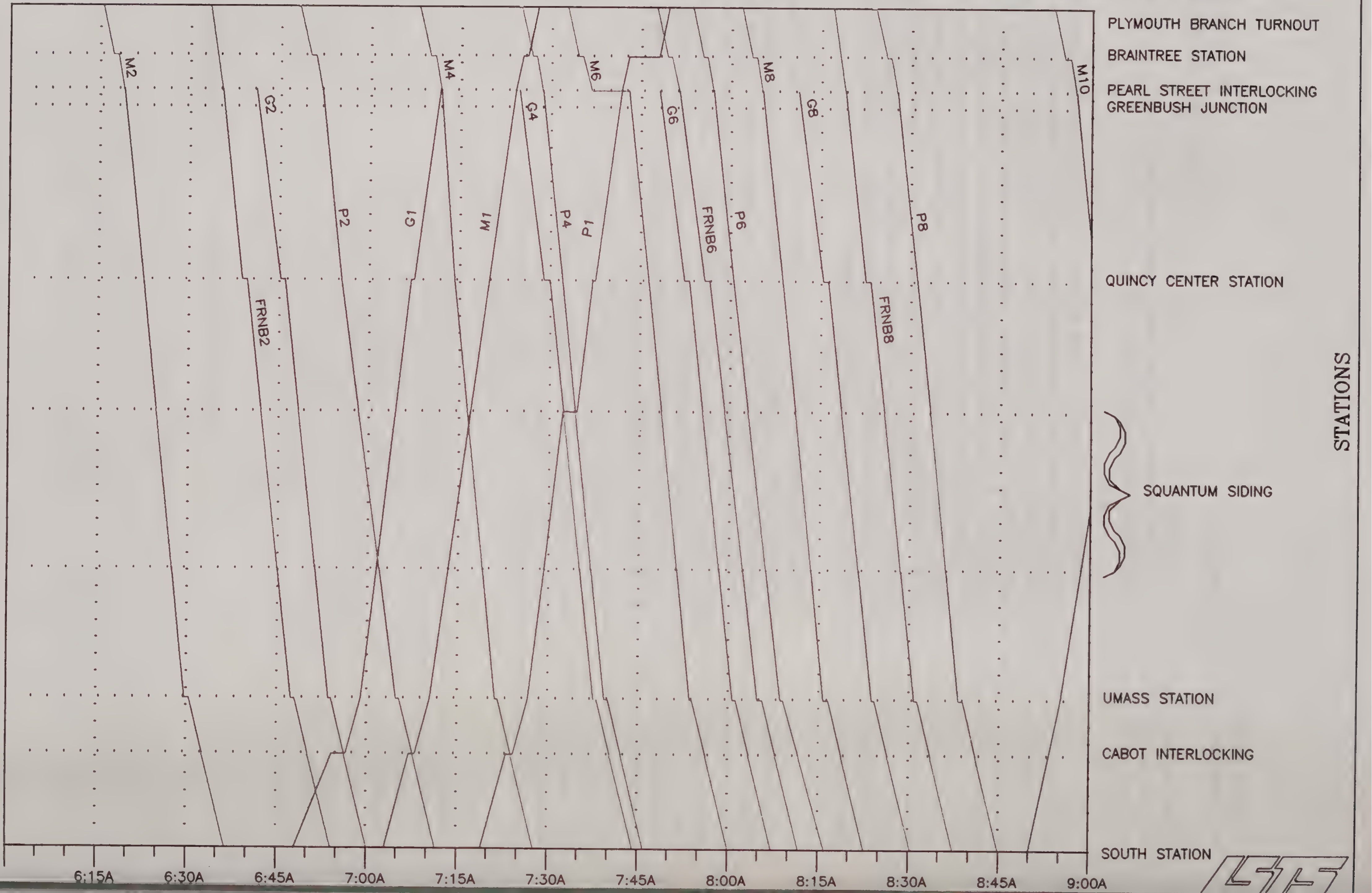


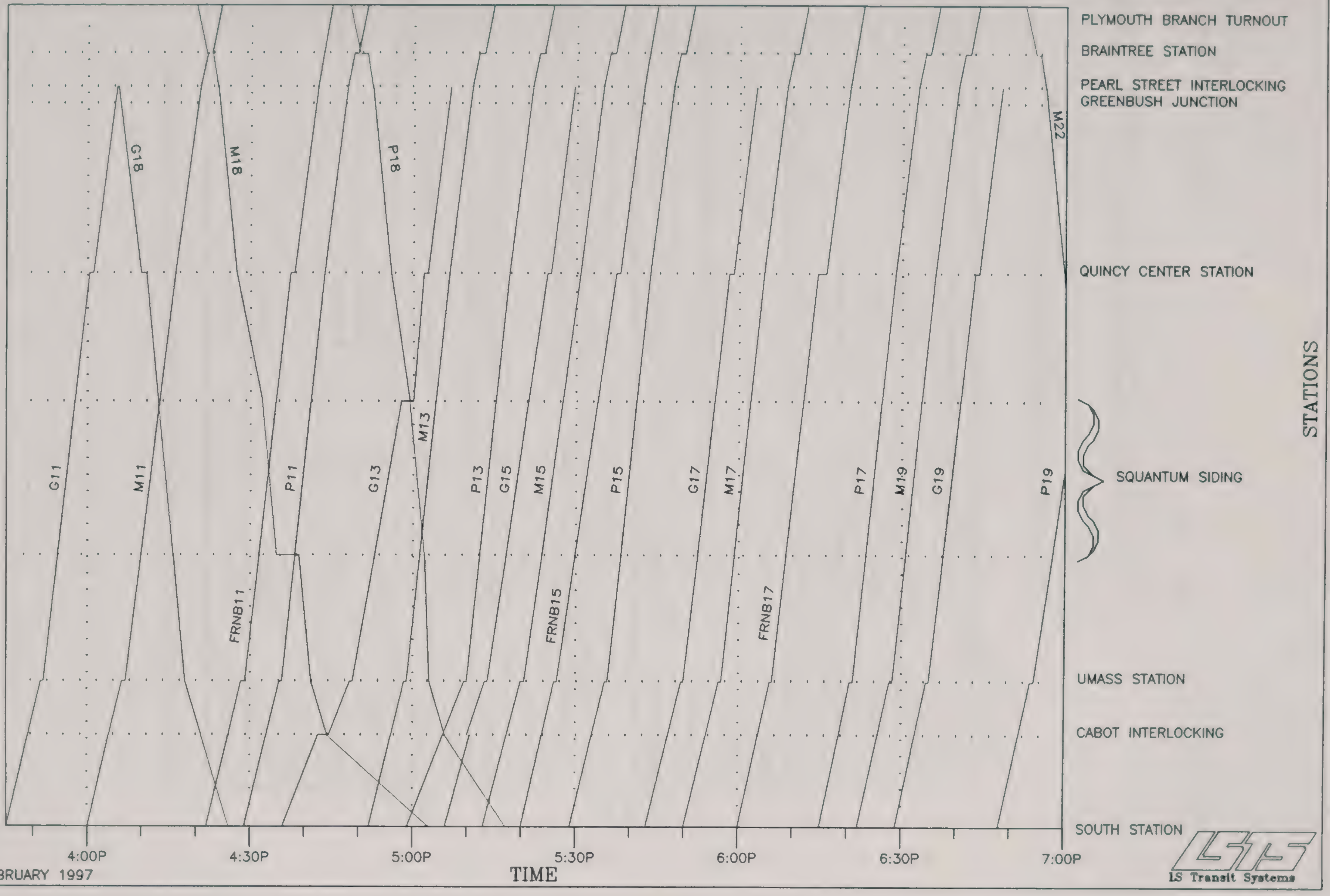
TABLE 2

MBTA NB/FR MIDDLEBORO ALTERNATIVE STUDY OPERATIONS SIMULATION REPORT

OLD COLONY MAIN LINE
PM PEAK PERIOD

LEGEND

- INBOUND TRACK – DOUBLE TRACK SEGMENTS
- OUTBOUND TRACK – DOUBLE TRACK SEGMENTS
- SINGLE TRACK SEGMENTS



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LS Transit Systems

Exhibit 1 displays the frequency of service and anticipated schedule for NB/FR service. A headway of basically 30 minutes peak period and 120 minutes off-peak was developed.

Exhibit 1
MIDDLEBORO ALTERNATIVE OPERATING PLAN

EASTWARD

TRAIN	ARR. SO.STA.	CLASS OF SERVICE	FREQUENCY
NB/FR02	7:00 AM	EXPRESS	--
NB/FR04	*7:39 AM•*	*EXPRESS*	*0:39*
NB/FR06	8:07 AM	EXPRESS	0:28
NB/FR08	8:37 AM	EXPRESS	0:30
NB/FR10	9:49 AM	LOCAL	1:12
NB/FR12	11:32 AM	LOCAL	1:43
NB/FR14	1:26 PM	LOCAL	1:54
NB/FR16	3:31 PM	LOCAL	2:05

WESTWARD

TRAIN	DEPART SO. STA.	CLASS OF SERVICE	FREQUENCY
NB/FR01	9:10 AM	LOCAL	--
NB/FR03	1:15 PM	LOCAL	4:05
NB/FR05	3:12 PM	LOCAL	1:57
NB/FR07	4:22 PM	EXPRESS	1:10
NB/FR09	*4:51 PM•*	*EXPRESS*	*0:29*
NB/FR11	5:20 PM	EXPRESS	0:29
NB/FR13	6:00 PM	EXPRESS	0:40
NB/FR15	6:48 PM	EXPRESS	0:48
NB/FR17	7:52 PM	LOCAL	1:04

• *This train can only be offered if reverse peak service on the Old Colony Lines is eliminated.*

5.3 ON-TIME PERFORMANCE: IDEAL SIMULATION, MORNING PEAK

The following table displays on-time performance eastbound at South Station during the morning peak period for the ideal simulation.

On-Time Performance at South Station, Ideal Operations
Peak Direction (Eastbound), 6-9 A.M.

On Time/Early	0:01-1 min	1:01-3 min	3:01-5 min	5:00+	Total
14	1	0	0	0	15

Without New Bedford/Fall River Trains

On Time/Early	0:01-1 min	1:01-3 min	3:01-5 min	5:00+	Total
10	2	0	0	0	12

5.4 ON-TIME PERFORMANCE: IDEAL SIMULATION, EVENING PEAK

The following table displays westbound on-time performance for the evening peak. The common point of the locations selected is that they are all the closest point from which train services have left the Old Colony Main Line, with its dense train operations. Note: The Plymouth and Greenbush branches were not built in the simulation beyond their respective points of divergence from the Main Line.

On-Time Performance at Selected Locations, Ideal Operations
Peak Direction (Westbound), 4-7 P.M.

	On Time/Early	0:01-1 min	1:01-3 min	3:01-5 min	5:00+	Total
Holbrook/Randolph						
NB/FR trains	0	0	4	0	0	4
Holbrook/Randolph						
Middleboro (run-throughs)	0	1	4	0	0	5
Pearl St. turnout						
Plymouth	4	0	0	0	0	4
Greenbush Jct. turnout						
Greenbush	0	5	0	0	0	5

Ideal Operations, Without New Bedford/Fall River Trains

	On Time/Early	0:01-1 min	1:01-3 min	3:01-5 min	5:00+	Total
Holbrook/Randolph						
Middleboro	0	5	0	0	0	5
Pearl St. turnout						
Plymouth	0	4	0	0	0	4
Greenbush Jct. turnout						
Greenbush	0	5	0	0	0	5

The above tables show that additional NB/FR trains do not adversely affect idealized operations on the Old Colony. It should be noted that coach yard moves in the South Station plant were not modeled, eliminating a sources of potential delay and greatly simplifying operations. The results of these tables include reverse peak service for the Old Colony branches.

5.5 ON-TIME PERFORMANCE: SIMULATED DELAYS

The final set of on-time performance tables for the Middleboro alternative displays the results of simulated delays to the Old Colony, including the NB/FR schedule. Simulation delays attempt to mimic real-world variations in station dwells and late-running trains. For the first iteration, delays were randomly given at outlying terminals during the a.m. peak. This simulates incidents that cause trains to lose schedule during the course of their run.

Trains were permitted to be up to two minutes early and up to five minutes late, with an offset of 75 seconds (i.e., the curve is skewed by 75 seconds of lateness) and a standard deviation of 150 seconds. Station dwell time was randomly lengthened at scheduled stops on all trains. The parameters used for station dwell delay were from ten seconds less time to sixty seconds more time at any random station.

These profiles were developed through past experience with the MBTA and on other properties to reflect reality. Station dwells can vary from one day to another due to passenger volume, accommodating trainmen waiting for tardy riders, weather conditions, and the needs of some commuters for extra time to board or alight.

The following table shows on-time performance at South Station for the delay-simulated scenario. Reverse peak service to the three Old Colony branches is included.

On-Time Performance at South Station, With Simulated Delays
Peak Direction (Eastbound), 6-9 A.M.

On Time/Early	0:01-1 min	1:01-3 min	3:01-5 min	5:00+	Total
0	7	5	1	2	15

The number of late trains and the degree of tardiness has increased. The railroad operation is much less complex than those prepared for the other alternatives (no High Speed Amtrak service, fewer trains overall). Coach yard moves in the South Station plant were not modeled, thus excluding a major source of potential delay that would have further reduced on-time efficiency.

The last on-time performance table for the Middleboro alternative displays the results of delay simulated operations in the p.m. peak. MBTA trains received the same random train delay parameters at South Station described above in the a.m. peak for outlying terminals. MBTA trains also received the random station dwell delay. The common point in the following table for the locations selected for on-time performance measurement is that they are all the closest point from which the various rail services have left the Old Colony Main Line, with its dense train operations. All of the routes have some remaining mileage on their runs with which to make up schedule.

On-Time Performance at Selected Locations,
With Simulated Delays, *Peak Direction (Westbound), 4-7 P.M.*

	On Time/Early	0:01-1 min	1:01-3 min	3:01-5 min	5:00+	Total
Holbrook/Randolph						
NB/FR trains	0	0	2	2	0	4
Holbrook/Randolph						
Middleboro (run-throughs)	0	0	2	2	1	5
Pearl St. turnout						
Plymouth	1	2	0	1	0	4
Greenbush Jct. turnout						
Greenbush	0	1	2	1	1	5

The number of late trains has greatly increased. The Old Colony Main Line, with its several segments of single track, requires that trains keep on schedule flawlessly, so as to have seamless meets at the passing sidings and on the few sections of double track. When the delay simulation makes one train late, it automatically causes many more trains to also become late. Delayed meets and passings hold up opposing moves, in turn causing signal delays to following trains that were scheduled at the minimal seven minute headway. The full ramifications of the delay caused by one delayed meet/pass are not represented in the model because South Station plant operations were not included. If a continuous parade of late trains from the Old Colony were to be handled on the Fort Point Channel Bridge, they might be routed into platform tracks reserved for other MBTA trains and, therefore, cause delays to all other MBTA South Side services.

5.6 SIGNAL DELAY STATISTICS

Signal delay is a very good measure of the extent of conflicts caused to opposing and following trains operating on rail system. Signal delay minutes are calculated automatically by RAILSIM®. As previously explained, a signal delay is accrued when a train is slowed or stopped by a signal indication.

Below are the results for the Middleboro alternative during the period from 4:00 PM to 7:00 PM on the Old Colony Main Line. The methodology involved running the ideal simulation with and without the NB/FR trains and then with all trains under simulated delays. Results produced total signal delay and the percent changed for each simulation.

Simulation	Total Signal Delay	Percent Change
NB/FR suspended	55 minutes 53 seconds	(datum)
All trains	78 minutes 30 seconds	40.5%
All trains, delay simulated	87 minutes 20 seconds	56.3%

Adding NB/FR trains to the Old Colony Main Line adds additional congestion to a single-track railroad that is already approaching a high level of density. The Old Colony itself will be subject to many delays if the service is not flawlessly operated. With NB/FR routed via Middleboro, the greater number of trains increases the likelihood of one late train disrupting at least a major part of the peak period. It should be noted that a majority of signal delay minutes of the NB/FR suspended simulation are for reverse peak trains at scheduled meet points.

6.0 CONCLUSIONS

The goal of this project was to determine the level of service to New Bedford/Fall River along the Middleboro Line of the Old Colony branch. The findings of this study, show that 18 trains are possible but difficult to recommend due to an extremely fragile operating plan. The tighter headway on the Old Colony Main Line creates a condition for the MBTA of greater exposure to potential delays for service to four lines (Middleboro, Plymouth, Greenbush and New Bedford/Fall River). In the event that a PM peak outbound train became disabled on the single track portion of the line, it could actually become entrapped on the line by the accumulated following peak hour trains. A rescue engine from the south terminus would be required to retrieve the failed equipment. The resulting delay could actually impact operations back to South Station. This is also true for a morning peak period except that a rescue engine could be dispatched from South Station thereby minimizing the delay. It should be noted that one disabled train on the Old Colony Main Line would virtually eliminate service to/from four commuter rail lines. This condition could possibly exist under the Old Colony opening day operating plan. However, it would not be prudent to add more trains to an already overcrowded and critical portion of the MBTA commuter rail system..

In comparison with the Attleboro Bypass and Stoughton line operational simulations, the Middleboro paled in comparison by only supporting 18 trains. The Middleboro produced a slightly longer running time of 1 hour and 17 minutes tandem express and 1 hour and 22 minutes off-peak locals. The mileage on the Middleboro Line from South Station to New Bedford and to Fall River would be 60 miles and 57 miles, respectively.

Unlike the Stoughton line simulation, no additional communities were served with this analysis. Service to Lakeville Station received the planned Old Colony service only. The Middleboro signal delay minutes were slightly higher than Stoughton and slightly less than the Attleboro alternatives. This should not be construed as an equal comparison to that of the two other alternatives, because Middleboro supports far fewer trains on a single track than the other two which operate on two and three track lines.

The infrastructure of the Middleboro Line was not designed to support this level of service and, due to the greater potential for delays, translates into a fragile operating plan.

AIR QUALITY APPENDIX

- Air Quality Modeling Protocol
- MOBILE5a-h Input Files
- MOBILE5a-h Output Summary
- Microscale Intersection Maps
- CAL3QHC Input Files
- CAL3QHC Output Files
- Microscale Results Summary
- Mesoscale Analysis

Air Quality Modeling Protocol

Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Department of Environmental Protection

William F. Weld
Governor
Argeo Paul Cellucci
Lt. Governor

Trudy Coxe
Secretary
David B. Struhs
Commissioner

September 15, 1995

Andrew Brennan
MBTA
Ten Park Plaza
Boston, MA 02116-3974

Dear Mr. Brennan:

The Department of Environmental Protection (DEP) Division of Air Quality Control (DAQC) has reviewed the air quality modelling protocol presented for the New Bedford/Fall River Commuter Rail Extension. DEP concurs with the intersections and roadway links chosen to represent the network's five stations as well as the placement of sensitive receptors for the microscale air quality analyses.

Should you have any questions concerning this correspondence, please contact Keith Grillo of the DAQC at 292-5773.

Sincerely,
Keith Grillo
Keith Grillo
Regional Planner

One Winter Street • Boston, Massachusetts 02108 • FAX (617) 556-1049 • Telephone (617) 292-5500

Printed on Recycled Paper

MOBILE5A INPUT FLAGS
1995 Modeling Analysis

Flag		Value/Procedure
TAMFLG	Tampering Rates	Use MOBILE5A defaults, Flag set to "1"
SPDFLG	Speed Flag	Use one speed for all vehicles, Flag set to "1"
VMFLAG	VMT Mix	Use MA average VMT mix, Flag set to "3"

Massachusetts Specific VMT Mix

LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
0.819	0.080	0.041	0.016	0.012	0.001	0.023	0.008

MYMRFG	Annual Mileage Accumulation and/or Registration Distribution by Age	Use MA registration distribution, Flag set to "3"

Massachusetts Statewide Registration Distribution

LDGV	.029 .064 .078 .094 .108 .111 .108 .093 .079 .053 .038 .032 .026 .026 .018 .011 .006 .004 .003 .003 .003 .002 .002 .001 .008
LDGT1	.033 .080 .086 .116 .139 .134 .102 .070 .055 .036 .024 .018 .014 .026 .020 .013 .007 .004 .004 .004 .003 .002 .002 .001 .007
LDGT2	.033 .080 .086 .116 .139 .134 .102 .070 .055 .036 .024 .018 .014 .026 .020 .013 .007 .004 .004 .004 .003 .002 .002 .001 .007
HDGV	.022 .050 .071 .112 .135 .131 .109 .065 .046 .027 .021 .023 .023 .031 .022 .015 .009 .010 .012 .014 .010 .007 .008 .006 .021
LDDV	.029 .064 .078 .094 .108 .111 .108 .093 .079 .053 .038 .032 .026 .026 .018 .011 .006 .004 .003 .003 .003 .002 .002 .001 .008
LDDT	.033 .080 .086 .116 .139 .134 .102 .070 .055 .036 .024 .018 .014 .026 .020 .013 .007 .004 .004 .004 .003 .002 .002 .001 .007
HDDV	.022 .050 .071 .112 .135 .131 .109 .065 .046 .027 .021 .023 .023 .031 .022 .015 .009 .010 .012 .014 .010 .007 .008 .006 .021
MC	.023 .054 .054 .063 .061 .068 .097 .079 .052 .062 .078 .309 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000

NEWFLG	Modified Exhaust Emission Rates	Use MOBILE5A defaults, Flag set to "1"

(Continued)

MOBILE5A INPUT FLAGS (Continued)
1995 Modeling Analyses

I/M Program Parameters

Flag		Value/Procedure
IMFLAG	Inspection and Maintenance	Use I/M Program, Flag set to "2"
	Start Year:	1983
	Stringency Level:	12%
	First Model Year:	1981
	Last Model Year:	2020
	Waiver Rate Pre-1981:	1%
	Waiver Rate 1981 & Post:	1%
	Compliance Rate:	80%
	Program Type:	Test & Repair
	Inspection Frequency:	Annual
	Vehicle Types Subject to Inspection:	LDGV, LDGT1, and LDGT2
	Test Type:	Idle Test
	User Supplied Non-default cutpoints:	No, use default cutpoints
	Alternate I/M credits:	None
ALHFLG	Exhaust Emission Correction Factors	No corrections modeled, Flag set to "1"
ATPFLG	Anti-Tampering Program	No program, Flag set to "1"
RLFLAG	Refueling Emission Factors	Stage II Vapor Recovery System modeled, Flag set to "2"

Vapor Recovery Program Inputs

Stage II Start Year:	1991
Phase In Period:	3 years
System Efficiency:	84% for LDGV & LDGT vehicle types 75% for HDGV vehicle type

(Continued)

MOBILE5A INPUT FLAGS (Continued)
1995 Modeling Analyses

LOCFLG	Local Area Parameter Record	One record for all scenarios, Flag set to "2"

Local Area Parameter Inputs

ASTM Class:	Use "C"
Minimum Temperature (°F):	68 for VOC; 35 for CO
Maximum Temperature (°F):	94 for VOC; 45 for CO
"Period 1" Reid Vapor Pressure:	11.5 psi for VOC; 13.5 psi for CO
"Period 2" Reid Vapor Pressure:	8.5 psi for VOC; 13.5 psi for CO
"Period 2" Start Year:	1989
Oxygenated Fuel Flag:	No oxygenated fuel program modeled, Flag set to "1"
Diesel Sales Fraction:	No alternative diesel sales fraction, Flag set to "1"
Reformulated Gasoline Flag:	Program modeled, Flag set to "2"

TEMFLG	Temperature Flag	Use LAP temperature range for VOC; use SCENARIO range for CO

MOBILE5A SCENARIO RECORD
1995 Modeling Analyses

Region	Low-altitude, Flag set to "1"
Calendar Year of Evaluation	1995 (Existing Conditions)
Average Speed	Varies from 3 to 65 mph in 1 mph increments, CO modeling included 2.5 mph
Ambient Temperature (°F)	87.8 for VOC; 40 for CO
Operating Mode Percents	20.6 / 27.3 / 20.6
Month of Evaluation	July, for VOC, Flag set to "7";January for CO, Flag set to "1"

MOBILE5A INPUT FLAGS
2005 Modeling Analyses

Flag		Value/Procedure
TAMFLG	Tampering Rates	Use MOBILE5A defaults, Flag set to "1"
SPDFLG	Speed Flag	Use one speed for all vehicles, Flag set to "1"
VMFLAG	VMT Mix	Use MA average VMT mix, Flag set to "3"

Massachusetts Specific VMT Mix

LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
0.823	0.062	0.032	0.026	0.011	0.001	0.039	0.006

MYMRFG	Annual Mileage Accumulation and/or Registration Distribution by Age	Use MA registration distribution, Flag set to "3"

Massachusetts Statewide Registration Distribution

LDGV	.029 .064 .078 .094 .108 .111 .108 .093 .079 .053 .038 .032 .026 .026 .018 .011 .006 .004 .003 .003 .003 .002 .002 .001 .008
LDGT1	.033 .080 .086 .116 .139 .134 .102 .070 .055 .036 .024 .018 .014 .026 .020 .013 .007 .004 .004 .004 .003 .002 .002 .001 .007
LDGT2	.033 .080 .086 .116 .139 .134 .102 .070 .055 .036 .024 .018 .014 .026 .020 .013 .007 .004 .004 .004 .003 .002 .002 .001 .007
HDGV	.022 .050 .071 .112 .135 .131 .109 .065 .046 .027 .021 .023 .023 .031 .022 .015 .009 .010 .012 .014 .010 .007 .008 .006 .021
LDDV	.029 .064 .078 .094 .108 .111 .108 .093 .079 .053 .038 .032 .026 .026 .018 .011 .006 .004 .003 .003 .003 .002 .002 .001 .008
LDDT	.033 .080 .086 .116 .139 .134 .102 .070 .055 .036 .024 .018 .014 .026 .020 .013 .007 .004 .004 .004 .003 .002 .002 .001 .007
HDDV	.022 .050 .071 .112 .135 .131 .109 .065 .046 .027 .021 .023 .023 .031 .022 .015 .009 .010 .012 .014 .010 .007 .008 .006 .021
MC	.023 .054 .054 .063 .061 .068 .097 .079 .052 .062 .078 .309 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000

NEWFLG	Modified Exhaust Emission Rates	Use MOBILE5A defaults, Flag set to "1"

(Continued)

MOBILE5A INPUT FLAGS (Continued)

2005 Modeling Analyses

Flag		Value/Procedure
IMFLAG	Inspection and Maintenance	Two I/M Programs, Flag set to "3"

I/M Program Parameters

Program Inputs	Idle I/M	Enhanced I/M
Start Year:	1983	1995
Stringency Level:	12%	20%
First Model Year:	1971	1981
Last Model Year:	1980	2020
Waiver Rate Pre-1981:	1%	1%
Waiver Rate 1981 & Post:	1%	1%
Compliance Rate:	80%	96%
Program Type:	Test & Repair	Test only
Inspection Frequency:	Biennial	Biennial
Vehicles Inspected:	LDGV, LDGT1, LDGT2, and HDGV	LDGV, LDGT1, LDGT2, and HDGV
Test Type:	Idle Test	IM240 Test
Non-default cutpoints:	Use Defaults	Yes
Alternate I/M credits:	None	None
HC cutpoint:	220	0.8
CO cutpoint:	1.2	15
NOx cutpoint:	999	2

ALHFLG	Exhaust Emission Corrections	No corrections, Flag set to "1"
ATPFLG	Anti-Tampering Program	Program with Pressure and Purge Test, Flag set to "8"

Anti-Tampering Program Parameters

Start Year:	1995
First Model Year:	1975
Last Model Year:	2020
Inspected Vehicle Types:	LDGV, LDGT1, LDGT2, and HDGV
Program Type:	Inspection only
Inspection Frequency:	Biennial
Compliance Rate:	98%
Test Type:	Air pump, Catalyst, Fuel inlet restrictor, EGR system, Evaporative controls, PCV system, and Gas caps

(Continued)

MOBILE5A INPUT FLAGS (Continued)

2005 Modeling Analyses

Flag		Value/Procedure
RLFLAG	Refueling Emission Factors	Stage II Vapor Recovery System modeled, Flag set to "2"

Vapor Recovery Program Inputs

Stage II Start Year:	1991
Phase In Period:	3 years
System Efficiency:	84% for LDGV & LDGT vehicle types 75% for HDGV vehicle type

LOCFLG	Local Area Parameter Record	One record for all scenarios, Flag set to "2"

Local Area Parameters Inputs

ASTM Class:	Use "C"
Minimum Temperature (°F):	68 for VOC; 35 for CO
Maximum Temperature (°F):	94 for VOC; 45 for CO
"Period 1" Reid Vapor Pressure:	11.5 psi for VOC; 13.5 for CO
"Period 2" Reid Vapor Pressure:	8.5 psi for VOC; 13.5 for CO
"Period 2" Start Year:	1989
Oxygenated Fuel Flag:	No oxygenated fuel program modeled, Flag set to "1"
Diesel Sales Fraction:	No alternative diesel sales fraction, Flag set to "1"
Reformulated Gasoline Flag:	Reformulated gasoline program modeled, Flag set to "2"

TEMFLG	Temperature Flag	Use LAP temperature range, Flag set to "1"

MOBILE5A SCENARIO RECORD

2005 Modeling Analyses

Region	Low-altitude, California vehicle program with standard I/M program, Flag set to "4"
Calendar Year of Evaluation	2005 (No Build and Build Conditions)
Average Speed	Varies from 3 to 65 mph in 1 mph increments; CO modeling included 2.5 mph
Ambient Temperature (°F)	87.8 for VOC; 40 for VOC
Operating Mode Percents	20.6 / 27.3 / 20.6
Month of Evaluation	July, for VOC, Flag set to "7"; January for CO, Flag set to "1"

LEV Program Parameters

LEV Program Phase-In Year	1994
I/M Program Type	Standard, Flag set to "1"

MICROSCALE MODELING ANALYSIS

Idle Emission Factor

The Idling Emission Factor will be developed using MOBILE5A with the flag settings as indicated for the microscale free-flow analysis, except with the speed set at 2.5 miles per hour. The resulting gram per vehicle-mile factor will be converted to grams per vehicle per hour by multipling by 2.5.

CAL3QHC Inputs

Averaging Time	60 Minutes
Surface Roughness	175 cm Commercial Areas 108 cm residential/open areas
Settling and Deposition velocity	0 cm/second
Windspeed	1 meter/second
Range of Wind Directions	10° increments from 0° to 360°
Stability Class	Use Class "D"
Mixing Height	1000 meters
Source Height	0.0 meters

Eight Hour Persistence Factor

Second Highest Carbon Monoxide Reading (ppm)
(1994 Monitoring Data)

Monitoring Site	One Hour	Eight Hour	Persistence Factor
Boston, Ma.			
Kenmore Square	5.4	3.7	0.68
Visconti Street	7.7	4.9	0.64
Breman Street	7.2	4.9	0.68
Federal Post Office Bldg.	7.7	5.9	0.77
Lowell, MA - Old City Hall	11.2	6.5	0.58

Average persistence factor is **0.67**

MOBILE5a-h Input Files

```
1          PROMPT - Vertical flag input, no prompting
MOBILE5A_h - 1998 Year - Massachusetts CO Parameters (March 27, 1998 DEP Guidance)
1          TAMFLG - Default tampering rates
1          SPDFLG - One speed per scenario for all vehicle types
3          VMFLAG - MA average VMT mix
3          MYMRFG - Massachusetts registration and default mileage accrual rates
1          NEWFLG - CAA ON- Default exhaust emission rates
22         IMFLAG - Enhanced I&M + tech training
1          ALHFLG - No additional correction factor inputs
8          ATPFLG - Full anti-tampering program with Pressure/Purge Tests
2          RLFLAG - Include stage II vapor recovery pogram
2          LOCFLG - Read in local area parameters one time for all scenarios
1          TEMFLG - Use max/min temps
4          OUTFMT - 80 column descriptive format
4          PRTFLG - Print VOC, CO, and NOx
2          IDLFLG - Print idle emissions results
3          NMHFLG - Print VOC [3-VOCs, 1-THCs, 2-NMHC, 4-TOG, 5-NMOG]
1          HCFLAG - No HC components
.823.062.032.026.011.001.039.006                    .MA 1998 VMT mix
.033 .079 .074 .077 .069 .064 .072 .083 .087 .087   .LDGV ages 1-10
.078 .060 .045 .026 .015 .011 .008 .008 .005 .003   .LDGV ages 11-20
.002 .001 .001 .001 .011                            .LDGV ages 21-25
.046 .103 .100 .080 .062 .054 .058 .073 .093 .083   .LDGT1 ages 1-10
.070 .051 .036 .019 .011 .008 .006 .012 .009 .006   .LDGT1 ages 11-20
.003 .002 .002 .002 .011                            .LDGT1 ages 21-25
.032 .082 .095 .075 .059 .046 .057 .082 .105 .083   .LDGT2 ages 1-10
.085 .057 .036 .021 .013 .010 .007 .014 .012 .007   .LDGT2 ages 11-20
.003 .002 .003 .003 .011                            .LDGT2 ages 21-25
.032 .100 .085 .059 .041 .032 .047 .072 .105 .087   .HDGV age 1-10
.088 .056 .036 .021 .014 .013 .013 .018 .015 .010   .HDGV age 11-20
.007 .006 .007 .007 .029                            .HDGV age 21-25
.033 .079 .074 .077 .069 .064 .072 .083 .087 .087   .LDDV age 1-10
.078 .060 .045 .026 .015 .011 .008 .008 .005 .003   .LDDV age 11-20
.002 .001 .001 .001 .011                            .LDDV age 21-25
.046 .103 .100 .080 .062 .054 .058 .073 .093 .083   .LDDT age 1-10
.070 .051 .036 .019 .011 .008 .006 .012 .009 .006   .LDDT age 11-20
.003 .002 .002 .002 .011                            .LDDT age 21-25
.046 .119 .080 .069 .046 .036 .047 .077 .080 .076   .HDDV age 1-10
.060 .044 .030 .017 .016 .018 .020 .024 .017 .011   .HDDV age 11-20
.006 .008 .009 .010 .034                            .HDDV age 21-25
.038 .070 .063 .054 .044 .033 .036 .043 .044 .049   .MC age 1-10
.068 .458 .000 .000 .000 .000 .000 .000 .000 .000   .MC age 11 & 12
.000 .000 .000 .000 .000                            .MC blank record
98 20 81 97 00 01 096 1 2 2222 4211 1.20 20.0 2.50 .ENH I/M data
98 81 97 2222 12 096. 22112212                     .ATP data
98 81 97 2222 12 096.                              .pressure data
98 81 97 2222 12 096.                              .purge data
91 3 084 084                                       .Stage II VRP data
MA 1998 DEP/IM98 C   35   45 13.5 13.5 89 1 1 2    .LAP record
4 98  2.5 40.0 50.0 10.0 50.0  1
94 1
4 98  3.0 40.0 50.0 10.0 50.0  1
94 1
4 98  4.0 40.0 50.0 10.0 50.0  1
94 1
4 98  5.0 40.0 50.0 10.0 50.0  1
94 1
4 98  6.0 40.0 50.0 10.0 50.0  1
94 1
…through….
4 98 65.0 40.0 50.0 10.0 50.0  1
94 1
```

```
1          PROMPT - Vertical flag input, no prompting
MOBILE5A_h - 2010 Year - Massachusetts CO Parameters (March 27, 1998 DEP Guidance)
1          TAMFLG - Default tampering rates
1          SPDFLG - One speed per scenario for all vehicle types
3          VMFLAG - MA average VMT mix
3          MYMRFG - Massachusetts registration and default mileage accrual rates
1          NEWFLG - CAA ON- Default exhaust emission rates
22         IMFLAG - Enhanced I&M + tech training
1          ALHFLG - No additional correction factor inputs
8          ATPFLG - Full anti-tampering program with Pressure/Purge Tests
2          RLFLAG - Include stage II vapor recovery pogram
2          LOCFLG - Read in local area parameters one time for all scenarios
1          TEMFLG - Use max/min temps
4          OUTFMT - 80 column descriptive format
4          PRTFLG - Print VOC, CO, and NOx
2          IDLFLG - Print idle emissions results
3          NMHFLG - Print VOC [3-VOCs, 1-THCs, 2-NMHC, 4-TOG, 5-NMOG]
1          HCFLAG - No HC components
.823.062.032.026.011.001.039.006                     .MA 1996 VMT mix
.033 .079 .074 .077 .069 .064 .072 .083 .087 .087    .LDGV ages 1-10
.078 .060 .045 .026 .015 .011 .008 .008 .005 .003    .LDGV ages 11-20
.002 .001 .001 .001 .011                             .LDGV ages 21-25
.046 .103 .100 .080 .062 .054 .058 .073 .093 .083    .LDGT1 ages 1-10
.070 .051 .036 .019 .011 .008 .006 .012 .009 .006    .LDGT1 ages 11-20
.003 .002 .002 .002 .011                             .LDGT1 ages 21-25
.032 .082 .095 .075 .059 .046 .057 .082 .105 .083    .LDGT2 ages 1-10
.085 .057 .036 .021 .013 .010 .007 .014 .012 .007    .LDGT2 ages 11-20
.003 .002 .003 .003 .011                             .LDGT2 ages 21-25
.032 .100 .085 .059 .041 .032 .047 .072 .105 .087    .HDGV age 1-10
.088 .056 .036 .021 .014 .013 .013 .018 .015 .010    .HDGV age 11-20
.007 .006 .007 .007 .029                             .HDGV age 21-25
.033 .079 .074 .077 .069 .064 .072 .083 .087 .087    .LDDV age 1-10
.078 .060 .045 .026 .015 .011 .008 .008 .005 .003    .LDDV age 11-20
.002 .001 .001 .001 .011                             .LDDV age 21-25
.046 .103 .100 .080 .062 .054 .058 .073 .093 .083    .LDDT age 1-10
.070 .051 .036 .019 .011 .008 .006 .012 .009 .006    .LDDT age 11-20
.003 .002 .002 .002 .011                             .LDDT age 21-25
.046 .119 .080 .069 .046 .036 .047 .077 .080 .076    .HDDV age 1-10
.060 .044 .030 .017 .016 .018 .020 .024 .017 .011    .HDDV age 11-20
.006 .008 .009 .010 .034                             .HDDV age 21-25
.038 .070 .063 .054 .044 .033 .036 .043 .044 .049    .MC age 1-10
.068 .458 .000 .000 .000 .000 .000 .000 .000 .000    .MC age 11 & 12
.000 .000 .000 .000 .000                             .MC blank record
98 20 81 10 00 01 096 1 2 2222 4211 1.20 20.0 2.50 .ENH I/M data
98 81 10 2222 12 096. 22112212                     .ATP data
98 81 10 2222 12 096.                              .pressure data
98 81 10 2222 12 096.                              .purge data
91 3 084 084                                       .Stage II VRP data
MA 2010 DEP/IM98 C   35   45 13.5 13.5 89 1 1 2    .LAP record
4 10  2.5 40.0 50.0 10.0 50.0  1
94 1
4 10  3.0 40.0 50.0 10.0 50.0  1
94 1
4 10  4.0 40.0 50.0 10.0 50.0  1
94 1
4 10  5.0 40.0 50.0 10.0 50.0  1
94 1
4 10  6.0 40.0 50.0 10.0 50.0  1
94 1
…through….
4 10 65.0 40.0 50.0 10.0 50.0  1
94 1
```

```
1          PROMPT - Vertical flag input, no prompting
MOBILE5A_h - 1998 Year - Massachusetts Ozone Parameters (March 27, 1998 DEP Guidance)
1          TAMFLG - Default tampering rates
1          SPDFLG - One speed per scenario for all vehicle types
3          VMFLAG - MA average VMT mix
3          MYMRFG - Massachusetts registration and default mileage accrual rates
1          NEWFLG - CAA ON- Default exhaust emission rates
22         IMFLAG - Enhanced I&M + tech training
1          ALHFLG - No additional correction factor inputs
8          ATPFLG - Full anti-tampering program with Pressure/Purge Tests
2          RLFLAG - Include stage II vapor recovery pogram
2          LOCFLG - Read in local area parameters one time for all scenarios
1          TEMFLG - Use max/min temps
4          OUTFMT - 80 column descriptive format
4          PRTFLG - Print VOC, CO, and NOx
2          IDLFLG - Print idle emissions results
3          NMHFLG - Print VOC [3-VOCs, 1-THCs, 2-NMHC, 4-TOG, 5-NMOG]
1          HCFLAG - No HC components
.823.062.032.026.011.001.039.006                    .MA 1998 VMT mix
.033 .079 .074 .077 .069 .064 .072 .083 .087 .087   .LDGV ages 1-10
.078 .060 .045 .026 .015 .011 .008 .008 .005 .003   .LDGV ages 11-20
.002 .001 .001 .001 .011                            .LDGV ages 21-25
.046 .103 .100 .080 .062 .054 .058 .073 .093 .083   .LDGT1 ages 1-10
.070 .051 .036 .019 .011 .008 .006 .012 .009 .006   .LDGT1 ages 11-20
.003 .002 .002 .002 .011                            .LDGT1 ages 21-25
.032 .082 .095 .075 .059 .046 .057 .082 .105 .083   .LDGT2 ages 1-10
.085 .057 .036 .021 .013 .010 .007 .014 .012 .007   .LDGT2 ages 11-20
.003 .002 .003 .003 .011                            .LDGT2 ages 21-25
.032 .100 .085 .059 .041 .032 .047 .072 .105 .087   .HDGV age 1-10
.088 .056 .036 .021 .014 .013 .013 .018 .015 .010   .HDGV age 11-20
.007 .006 .007 .007 .029                            .HDGV age 21-25
.033 .079 .074 .077 .069 .064 .072 .083 .087 .087   .LDDV age 1-10
.078 .060 .045 .026 .015 .011 .008 .008 .005 .003   .LDDV age 11-20
.002 .001 .001 .001 .011                            .LDDV age 21-25
.046 .103 .100 .080 .062 .054 .058 .073 .093 .083   .LDDT age 1-10
.070 .051 .036 .019 .011 .008 .006 .012 .009 .006   .LDDT age 11-20
.003 .002 .002 .002 .011                            .LDDT age 21-25
.046 .119 .080 .069 .046 .036 .047 .077 .080 .076   .HDDV age 1-10
.060 .044 .030 .017 .016 .018 .020 .024 .017 .011   .HDDV age 11-20
.006 .008 .009 .010 .034                            .HDDV age 21-25
.038 .070 .063 .054 .044 .033 .036 .043 .044 .049   .MC age 1-10
.068 .458 .000 .000 .000 .000 .000 .000 .000 .000   .MC age 11 & 12
.000 .000 .000 .000 .000                            .MC blank record
98 20 81 97 00 01 096 1 2 2222 4211 1.20 20.0 2.50 .ENH I/M data
98 81 97 2222 12 096. 22112212                     .ATP data
98 81 97 2222 12 096.                              .pressure data
98 81 97 2222 12 096.                              .purge data
91 3 084 084                                       .Stage II VRP data
MA 1998 DEP/IM98 C   68   94 11.5  9.0 89 1 1 2    .LAP record
4 98  2.5 85.4 20.6 27.3 20.6  7
94 1
4 98  3.0 85.4 20.6 27.3 20.6  7
94 1
4 98  4.0 85.4 20.6 27.3 20.6  7
94 1
4 98  5.0 85.4 20.6 27.3 20.6  7
94 1
4 98  6.0 85.4 20.6 27.3 20.6  7
94 1
…through….
4 98 65.0 85.4 20.6 27.3 20.6  7
94 1
```

```
1          PROMPT - Vertical flag input, no prompting
MOBILE5A_h - 2010 Year - Massachusetts Ozone Parameters (March 27, 1998 DEP Guidance)
1          TAMFLG - Default tampering rates
1          SPDFLG - One speed per scenario for all vehicle types
3          VMFLAG - MA average VMT mix
3          MYMRFG - Massachusetts registration and default mileage accrual rates
1          NEWFLG - CAA ON- Default exhaust emission rates
22         IMFLAG - Enhanced I&M + tech training
1          ALHFLG - No additional correction factor inputs
8          ATPFLG - Full anti-tampering program with Pressure/Purge Tests
2          RLFLAG - Include stage II vapor recovery pogram
2          LOCFLG - Read in local area parameters one time for all scenarios
1          TEMFLG - Use max/min temps
4          OUTFMT - 80 column descriptive format
4          PRTFLG - Print VOC, CO, and NOx
2          IDLFLG - Print idle emissions results
3          NMHFLG - Print VOC [3-VOCs, 1-THCs, 2-NMHC, 4-TOG, 5-NMOG]
1          HCFLAG - No HC components
.823.062.032.026.011.001.039.006                    .MA 1996 VMT mix
.033 .079 .074 .077 .069 .064 .072 .083 .087 .087   .LDGV ages 1-10
.078 .060 .045 .026 .015 .011 .008 .008 .005 .003   .LDGV ages 11-20
.002 .001 .001 .001 .011                            .LDGV ages 21-25
.046 .103 .100 .080 .062 .054 .058 .073 .093 .083   .LDGT1 ages 1-10
.070 .051 .036 .019 .011 .008 .006 .012 .009 .006   .LDGT1 ages 11-20
.003 .002 .002 .002 .011                            .LDGT1 ages 21-25
.032 .082 .095 .075 .059 .046 .057 .082 .105 .083   .LDGT2 ages 1-10
.085 .057 .036 .021 .013 .010 .007 .014 .012 .007   .LDGT2 ages 11-20
.003 .002 .003 .003 .011                            .LDGT2 ages 21-25
.032 .100 .085 .059 .041 .032 .047 .072 .105 .087   .HDGV age 1-10
.088 .056 .036 .021 .014 .013 .013 .018 .015 .010   .HDGV age 11-20
.007 .006 .007 .007 .029                            .HDGV age 21-25
.033 .079 .074 .077 .069 .064 .072 .083 .087 .087   .LDDV age 1-10
.078 .060 .045 .026 .015 .011 .008 .008 .005 .003   .LDDV age 11-20
.002 .001 .001 .001 .011                            .LDDV age 21-25
.046 .103 .100 .080 .062 .054 .058 .073 .093 .083   .LDDT age 1-10
.070 .051 .036 .019 .011 .008 .006 .012 .009 .006   .LDDT age 11-20
.003 .002 .002 .002 .011                            .LDDT age 21-25
.046 .119 .080 .069 .046 .036 .047 .077 .080 .076   .HDDV age 1-10
.060 .044 .030 .017 .016 .018 .020 .024 .017 .011   .HDDV age 11-20
.006 .008 .009 .010 .034                            .HDDV age 21-25
.038 .070 .063 .054 .044 .033 .036 .043 .044 .049   .MC age 1-10
.068 .458 .000 .000 .000 .000 .000 .000 .000 .000   .MC age 11 & 12
.000 .000 .000 .000 .000                            .MC blank record
98 20 81 10 00 01 096 1 2 2222 4211 1.20 20.0 2.50 .ENH I/M data
98 81 10 2222 12 096. 22112212                     .ATP data
98 81 10 2222 12 096.                              .pressure data
98 81 10 2222 12 096.                              .purge data
91 3 084 084                                       .Stage II VRP data
MA 2005 DEP/IM98 C   68   94 11.5  9.0 89 1 1 2    .LAP record
4 10  2.5 85.4 20.6 27.3 20.6  7
94 1
4 10  3.0 85.4 20.6 27.3 20.6  7
94 1
4 10  4.0 85.4 20.6 27.3 20.6  7
94 1
4 10  5.0 85.4 20.6 27.3 20.6  7
94 1
4 10  6.0 85.4 20.6 27.3 20.6  7
94 1
…through….
4 10 65.0 85.4 20.6 27.3 20.6  7
94 1
```

MOBILE5a-h Output Summary

1998 Microscale Analysis
Carbon Monoxide Emission Factors

Vehicle Speed (mph)	Emission Factor (g/veh-mile)
2.5	158.37
3	135.10
4	105.67
5	87.79
6	75.74
7	67.08
8	60.54
9	55.42
10	51.32
11	47.95
12	45.14
13	42.75
14	40.70
15	38.92
16	37.36
17	35.98
18	34.75
19	33.65
20	32.33
21	30.75
22	29.31
23	28.00
24	26.80
25	25.69
26	24.66
27	23.72
28	22.84
29	22.02
30	21.25
31	20.54
32	19.87
33	19.24
34	18.65
35	18.10
36	17.57
37	17.08
38	16.62
39	16.18
40	15.76
41	15.37
42	14.99
43	14.64
44	14.30
45	13.98
46	13.68
47	13.39
48	13.11
49	13.12
50	13.12
51	13.13
52	13.13
53	13.14
54	13.15
55	13.17
56	14.59
57	16.01
58	17.44
59	18.87
60	20.30
61	21.73
62	23.16
63	24.60
64	26.04
65	27.48

NOTE: Emission factors were calculated by MOBILE5a-h and represent a composite vehicle type during winter conditions.

2010 Microscale Analysis
Carbon Monoxide Emission Factors

Vehicle Speed (mph)	Emission Factor (g/veh-mile)
2.5	69.28
3	59.48
4	47.10
5	39.57
6	34.48
7	30.81
8	28.02
9	25.84
10	24.08
11	22.63
12	21.42
13	20.38
14	19.49
15	18.72
16	18.04
17	17.44
18	16.90
19	16.42
20	15.73
21	14.85
22	14.06
23	13.33
24	12.67
25	12.06
26	11.49
27	10.97
28	10.48
29	10.03
30	9.61
31	9.22
32	8.85
33	8.50
34	8.18
35	7.87
36	7.59
37	7.31
38	7.06
39	6.81
40	6.59
41	6.37
42	6.16
43	5.96
44	5.78
45	5.60
46	5.43
47	5.27
48	5.12
49	5.12
50	5.12
51	5.13
52	5.13
53	5.14
54	5.14
55	5.15
56	5.59
57	6.02
58	6.46
59	6.90
60	7.34
61	7.79
62	8.23
63	8.68
64	9.12
65	9.57

NOTE: Emission factors were calculated by MOBILE5a-h and represent a composite vehicle type during winter conditions.

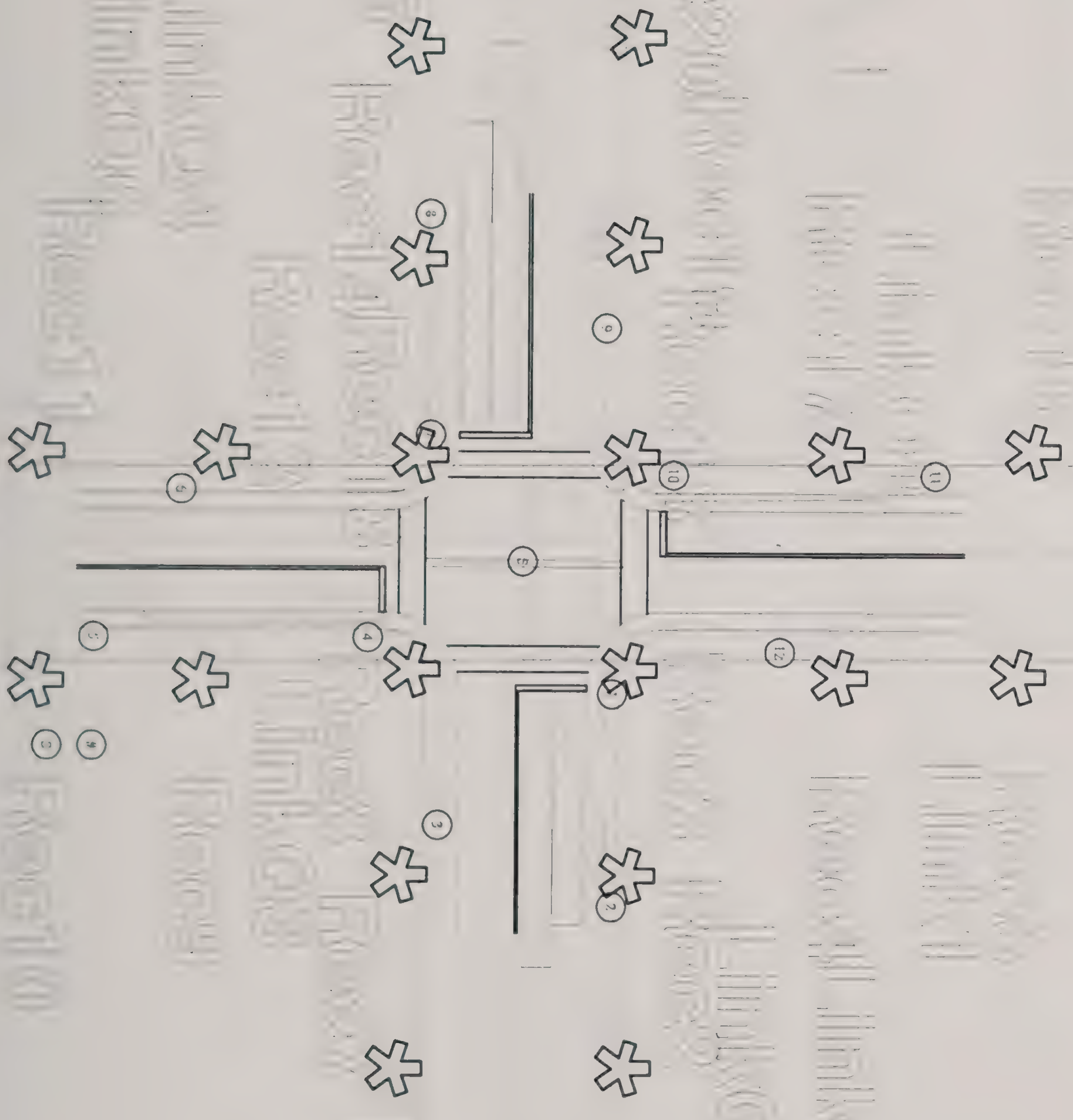
Year 1998 Emission Factor Summary, LDGV Vehicles Only

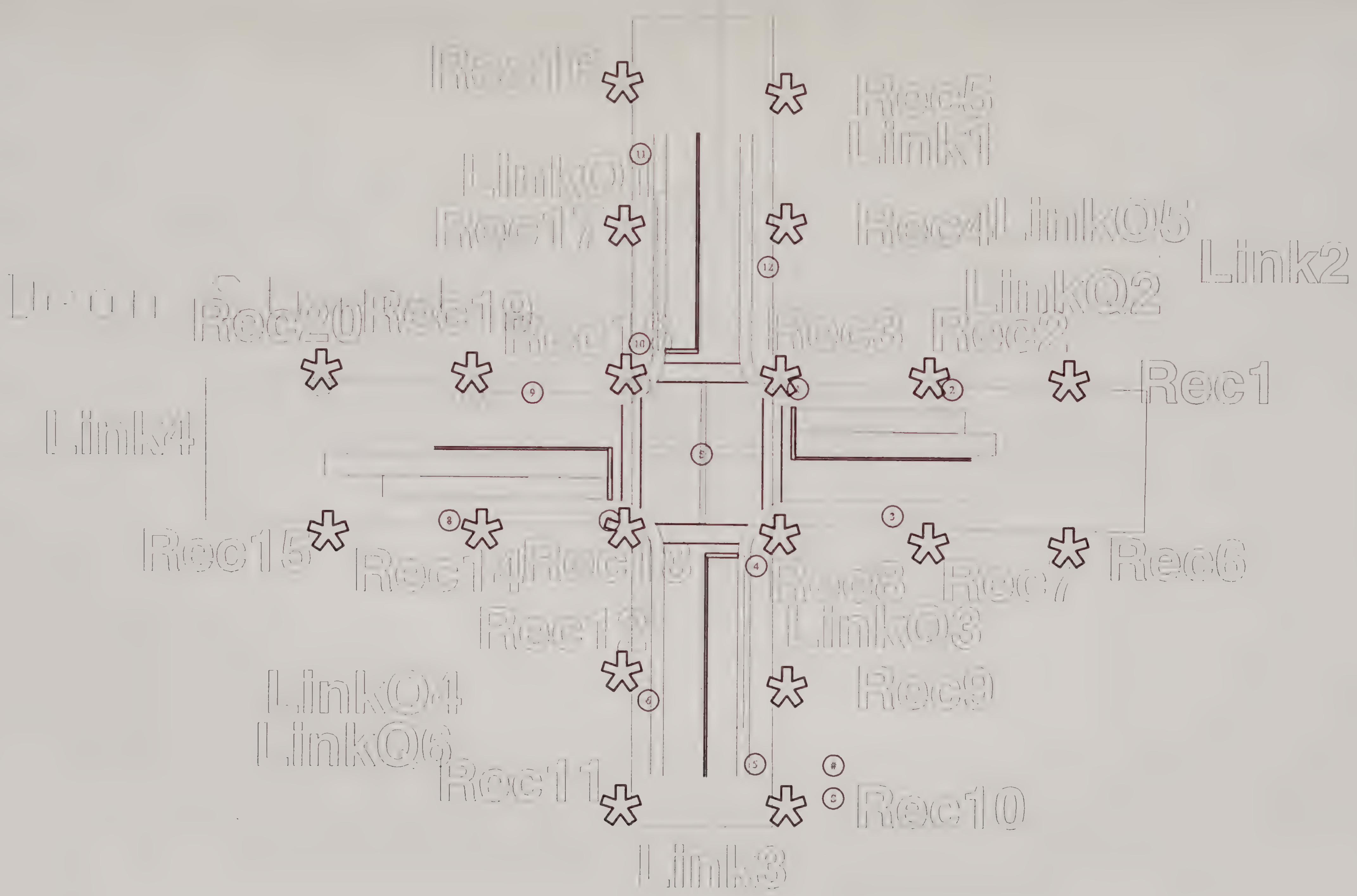
	Emission Factor (g/mi)		
Speed	VOC	CO	NOx
2.5	10.80	162.68	2.11
3	8.80	138.23	1.97
4	6.48	107.52	1.80
5	5.19	89.00	1.70
6	4.37	76.62	1.64
7	3.81	67.77	1.59
8	3.47	61.13	1.55
9	3.21	55.97	1.52
10	2.99	51.85	1.50
11	2.80	48.48	1.48
12	2.63	45.67	1.47
13	2.49	43.30	1.46
14	2.36	41.27	1.44
15	2.23	39.51	1.44
16	2.12	37.97	1.43
17	2.02	36.61	1.42
18	1.92	35.40	1.41
19	1.83	34.32	1.41
20	1.75	32.97	1.41
21	1.69	31.35	1.42
22	1.63	29.88	1.43
23	1.58	28.53	1.43
24	1.53	27.30	1.44
25	1.49	26.16	1.45
26	1.44	25.11	1.45
27	1.41	24.14	1.46
28	1.37	23.23	1.46
29	1.33	22.39	1.47
30	1.30	21.61	1.47
31	1.27	20.87	1.47
32	1.24	20.18	1.48
33	1.21	19.53	1.48
34	1.18	18.92	1.48
35	1.16	18.35	1.49
36	1.13	17.81	1.49
37	1.11	17.30	1.49
38	1.09	16.81	1.50
39	1.07	16.35	1.50
40	1.04	15.92	1.50
41	1.02	15.50	1.50
42	1.00	15.11	1.51
43	0.99	14.73	1.51
44	0.97	14.38	1.51
45	0.95	14.04	1.51
46	0.93	13.71	1.51
47	0.92	13.40	1.52
48	0.90	13.10	1.52
49	0.90	13.10	1.57
50	0.90	13.10	1.62
51	0.89	13.10	1.67
52	0.89	13.10	1.72
53	0.89	13.10	1.77
54	0.89	13.10	1.82
55	0.89	13.10	1.87
56	0.91	14.55	1.92
57	0.93	15.99	1.97
58	0.95	17.44	2.02
59	0.97	18.88	2.08
60	0.99	20.33	2.13
61	1.01	21.77	2.18
62	1.03	23.22	2.23
63	1.05	24.66	2.28
64	1.07	26.11	2.33
65	1.09	27.56	2.38

Year 2010 Emission Factor Summary, LDGV Vehicles Only

	Emission Factor (g/mi)		
Speed	VOC	CO	NOx
2.5	4.28	68.17	1.21
3	3.47	58.15	1.13
4	2.55	45.63	1.04
5	2.05	38.11	0.98
6	1.74	33.10	0.94
7	1.52	29.53	0.91
8	1.39	26.84	0.89
9	1.29	24.76	0.87
10	1.21	23.09	0.86
11	1.14	21.72	0.85
12	1.08	20.58	0.84
13	1.03	19.62	0.83
14	0.98	18.79	0.83
15	0.94	18.08	0.82
16	0.90	17.45	0.82
17	0.87	16.90	0.81
18	0.84	16.41	0.81
19	0.82	15.97	0.81
20	0.78	15.30	0.81
21	0.75	14.43	0.81
22	0.73	13.64	0.82
23	0.70	12.93	0.82
24	0.68	12.27	0.83
25	0.66	11.66	0.83
26	0.64	11.10	0.83
27	0.62	10.59	0.84
28	0.60	10.11	0.84
29	0.59	9.66	0.84
30	0.57	9.24	0.84
31	0.56	8.85	0.85
32	0.55	8.48	0.85
33	0.53	8.14	0.85
34	0.52	7.82	0.85
35	0.51	7.51	0.85
36	0.50	7.22	0.86
37	0.49	6.95	0.86
38	0.48	6.69	0.86
39	0.47	6.45	0.86
40	0.46	6.21	0.86
41	0.45	5.99	0.86
42	0.45	5.78	0.86
43	0.44	5.58	0.87
44	0.43	5.39	0.87
45	0.42	5.21	0.87
46	0.42	5.03	0.87
47	0.41	4.86	0.87
48	0.40	4.70	0.87
49	0.40	4.70	0.90
50	0.40	4.70	0.92
51	0.40	4.70	0.95
52	0.40	4.70	0.97
53	0.40	4.70	1.00
54	0.40	4.70	1.02
55	0.40	4.70	1.05
56	0.41	5.12	1.07
57	0.41	5.54	1.10
58	0.42	5.97	1.12
59	0.43	6.39	1.15
60	0.44	6.81	1.17
61	0.45	7.23	1.20
62	0.46	7.65	1.22
63	0.47	8.08	1.25
64	0.47	8.50	1.27
65	0.48	8.92	1.30

Microscale Intersection Maps

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Rec5
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LinkQ1
Rec17
Rec4
LinkQ5
Link2
LinkQ2
Rec20
Rec19
Rec18
Rec3
Rec2
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Link4
Rec15
Rec14
Rec13
Rec8
Rec7
Rec6
Rec12
LinkQ3
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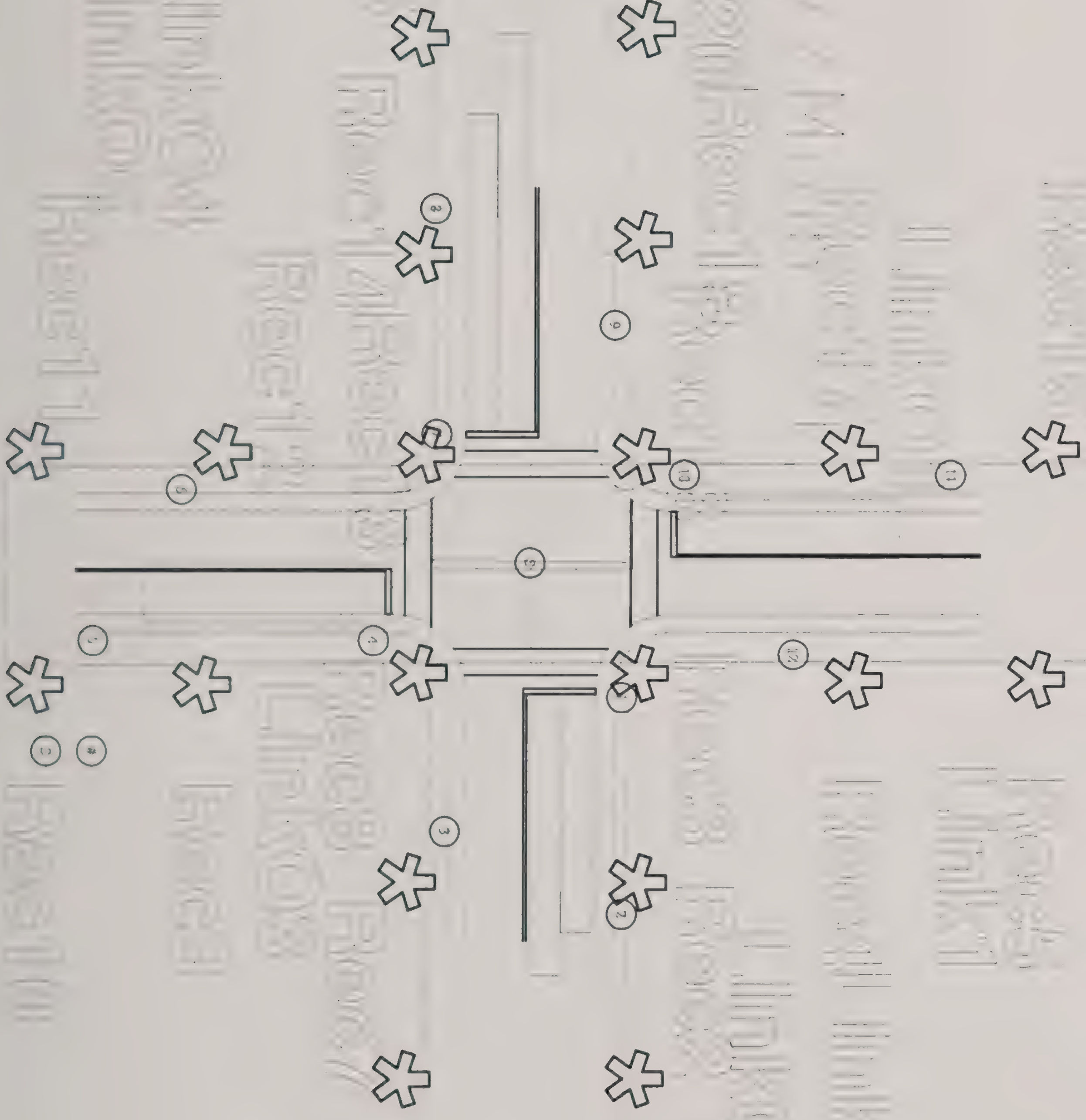

CAL3QHC Input Files

```
'NB/FR CommRail 1998 ExistCond'         60. 108. 0.   0.   20 0.3048 1 1
'Rec1'               333.      284.      6.
'Rec2'               268.      285.      6.
'Rec3'               199.      286.      6.
'Rec4'               201.      357.      6.
'Rec5'               201.      417.      6.
'Rec6'               333.      207.      6.
'Rec7'               268.      209.      6.
'Rec8'               199.      213.      6.
'Rec9'               203.      141.      6.
'Rec10'              203.      86.       6.
'Rec11'              125.      86.       6.
'Rec12'              125.      148.      6.
'Rec13'              126.      215.      6.
'Rec14'              59.       214.      6.
'Rec15'              -13.      213.      6.
'Rec16'              124.      422.      6.
'Rec17'              125.      355.      6.
'Rec18'              126.      286.      6.
'Rec19'              54.       287.      6.
'Rec20'              -16.      288.      6.
'Dean Street and Longmeadow Rd'          10  1   1  'C'
  1
'Link1'             'AG' 162.   250.   161.   452.    572.  32.3 0.  66.
  1
'Link2'             'AG' 161.   250.   369.   247.   2137.  21.3 0.  66.
  1
'Link3'             'AG' 162.   253.   163.   76.     682.  32.3 0.  66.
  1
'Link4'             'AG' 164.   251.   -70.   251.   1668.  21.3 0.  66.
  2
'LinkQ1'            'AG' 151.   298.   151.   372.   0.       20.    2
        60        40      3.0   307 395.9   1600 1 3
  2
'LinkQ2'            'AG' 205.   255.   299.   255.   0.       10.    1
        60        29      3.0   213 395.9   1600 1 3
  2
'LinkQ3'            'AG' 172.   203.   172.   122.   0.       20.    2
        60        40      3.0   247 395.9  1600 1 3
  2
'LinkQ4'            'AG' 119.   243.   -14.   244.   0.       10.    1
        60        29      3.0    10 395.9   1600 1 3
  2
'LinkQ5'            'AG' 205.   266.   285.   265.   0.       10.    1
        60        39      3.0   900 395.9   1600 1 3
  2
'LinkQ6'            'AG' 118.   234.   13.    234.   0.       10.    1
        60        39      3.0   857 395.9   1600 1 3
1. 0.  4 1000. 5.0 'Y' 10  0 36
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'NB/FR CommRail 2010 No Build'          60. 108. 0.   0.   20 0.3048 1 1
'Rec1'                   333.      284.      6.
'Rec2'                   268.      285.      6.
'Rec3'                   199.      286.      6.
'Rec4'                   201.      357.      6.
'Rec5'                   201.      417.      6.
'Rec6'                   333.      207.      6.
'Rec7'                   268.      209.      6.
'Rec8'                   199.      213.      6.
'Rec9'                   203.      141.      6.
'Rec10'                  203.      86.       6.
'Rec11'                  125.      86.       6.
'Rec12'                  125.      148.      6.
'Rec13'                  126.      215.      6.
'Rec14'                  59.       214.      6.
'Rec15'                  -13.      213.      6.
'Rec16'                  124.      422.      6.
'Rec17'                  125.      355.      6.
'Rec18'                  126.      286.      6.
'Rec19'                  54.       287.      6.
'Rec20'                  -16.      288.      6.
'Dean Street and Longmeadow Rd'          10  1   1  'C'
  1
'Link1'                 'AG' 162.   250.   161.   452.    648.  15.7 0.  66.
  1
'Link2'                 'AG' 161.   250.   369.   247.   2410.   9.6 0.  66.
  1
'Link3'                 'AG' 162.   253.   163.   76.     768.  15.7 0.  66.
  1
'Link4'                 'AG' 164.   251.   -70.   251.   1881.   9.6 0.  66.
  2
'LinkQ1'                'AG' 151.   298.   151.   372.   0.      20.    2
       60         40      3.0   350 173.2   1600 1 3
  2
'LinkQ2'                'AG' 205.   255.   299.   255.   0.      10.    1
       60         29      3.0   239 173.2   1600 1 3
  2
'LinkQ3'                'AG' 172.   203.   172.   122.   0.      20.    2
       60         40      3.0   277 173.2  1600 1 3
  2
'LinkQ4'                'AG' 119.   243.   -14.   244.   0.      10.    1
       60         29      3.0    10 173.2   1600 1 3
  2
'LinkQ5'                'AG' 205.   266.   285.   265.   0.      10.    1
       60         39      3.0  1015 173.2   1600 1 3
  2
'LinkQ6'                'AG' 118.   234.   13.    234.   0.      10.    1
       60         39      3.0   968 173.2   1600 1 3
1. 0.  4 1000. 5.0 'Y' 10  0 36
```

```
'NB/FR CommRail    2010 Build'          60. 108. 0.   0.   20 0.3048 1 1
'Rec1'                333.       284.       6.
'Rec2'                268.       285.       6.
'Rec3'                199.       286.       6.
'Rec4'                201.       357.       6.
'Rec5'                201.       417.       6.
'Rec6'                333.       207.       6.
'Rec7'                268.       209.       6.
'Rec8'                199.       213.       6.
'Rec9'                203.       141.       6.
'Rec10'               203.       86.        6.
'Rec11'               125.       86.        6.
'Rec12'               125.       148.       6.
'Rec13'               126.       215.       6.
'Rec14'               59.        214.       6.
'Rec15'               -13.       213.       6.
'Rec16'               124.       422.       6.
'Rec17'               125.       355.       6.
'Rec18'               126.       286.       6.
'Rec19'               54.        287.       6.
'Rec20'               -16.       288.       6.
'Dean Street and Longmeadow Rd'          10  1   1  'C'
  1
'Link1'                'AG' 162.   250.   161.   452.    648.  15.7 0.  66.
  1
'Link2'                'AG' 161.   250.   369.   247.   2435.   9.6 0.  66.
  1
'Link3'                'AG' 162.   253.   163.   76.     768.  15.7 0.  66.
  1
'Link4'                'AG' 164.   251.   -70.   251.   1907.   9.6 0.  66.
  2
'LinkQ1'               'AG' 151.   298.   151.   372.   0.      20.    2
        60         40      3.0   350 173.2   1600 1 3
  2
'LinkQ2'               'AG' 205.   255.   299.   255.   0.      10.    1
        60         29      3.0   239 173.2   1600 1 3
  2
'LinkQ3'               'AG' 172.   203.   172.   122.   0.      20.    2
        60         40      3.0   277 173.2  1600 1 3
  2
'LinkQ4'               'AG' 119.   243.   -14.   244.   0.      10.    1
        60         29      3.0    10 173.2   1600 1 3
  2
'LinkQ5'               'AG' 205.   266.   285.   265.   0.      10.    1
        60         39      3.0  1258 173.2   1600 1 3
  2
'LinkQ6'               'AG' 118.   234.   13.    234.   0.      10.    1
        60         39      3.0   994 173.2   1600 1 3
1. 0.  4 1000. 5.0 'Y' 10  0 36
```

```
'NB/FR CommRail 1998 ExistCond'         60. 108. 0.   0.   20 0.3048 1 1
'Rec1'               333.      284.      6.
'Rec2'               268.      285.      6.
'Rec3'               199.      286.      6.
'Rec4'               201.      357.      6.
'Rec5'               201.      417.      6.
'Rec6'               333.      207.      6.
'Rec7'               268.      209.      6.
'Rec8'               199.      213.      6.
'Rec9'               203.      141.      6.
'Rec10'              203.      86.       6.
'Rec11'              125.      86.       6.
'Rec12'              125.      148.      6.
'Rec13'              126.      215.      6.
'Rec14'              59.       214.      6.
'Rec15'              -13.      213.      6.
'Rec16'              124.      422.      6.
'Rec17'              125.      355.      6.
'Rec18'              126.      286.      6.
'Rec19'              54.       287.      6.
'Rec20'              -16.      288.      6.
'Foundry St/Rt106 and Rte138 TpkSt'          8  1   1  'C'
  1
'Link1'             'AG' 162.   250.   161.   452.   1211.  18.1 0.  66.
  1
'Link2'             'AG' 161.   250.   369.   247.   1288.  21.3 0.  66.
  1
'Link3'             'AG' 162.   253.   163.   76.    1480.  18.1 0.  66.
  1
'Link4'             'AG' 164.   251.   -70.   251.    738.  21.3 0.  66.
  2
'LinkQ1'            'AG' 151.   298.   151.   372.   0.      20.    2
        60        28      3.0   768 395.9   1600 1 3
  2
'LinkQ2'            'AG' 205.   255.   299.   255.   0.      20.    2
        60        38      3.0   738 395.9   1600 1 3
  2
'LinkQ3'            'AG' 172.   203.   172.   122.   0.      20.    2
        70        38      3.0   516 395.9  1600 1 3
  2
'LinkQ4'            'AG' 119.   243.   -14.   244.   0.      20.    2
        70        38      3.0   337 395.9   1600 1 3
1. 0.  4 1000. 5.0 'Y' 10  0 36
```

```
'NB/FR CommRail 2010 No Build '         60. 108. 0.   0.   20 0.3048 1 1
'Rec1'               333.      284.      6.
'Rec2'               268.      285.      6.
'Rec3'               199.      286.      6.
'Rec4'               201.      357.      6.
'Rec5'               201.      417.      6.
'Rec6'               333.      207.      6.
'Rec7'               268.      209.      6.
'Rec8'               199.      213.      6.
'Rec9'               203.      141.      6.
'Rec10'              203.      86.       6.
'Rec11'              125.      86.       6.
'Rec12'              125.      148.      6.
'Rec13'              126.      215.      6.
'Rec14'              59.       214.      6.
'Rec15'              -13.      213.      6.
'Rec16'              124.      422.      6.
'Rec17'              125.      355.      6.
'Rec18'              126.      286.      6.
'Rec19'              54.       287.      6.
'Rec20'              -16.      288.      6.
'Foundry St/106 and Rte138 Tpk St'           8  1   1  'C'
  1
'Link1'             'AG' 162.   250.   161.   452.   1369.   7.9 0.  66.
  1
'Link2'             'AG' 161.   250.   369.   247.   1454.   9.6 0.  66.
  1
'Link3'             'AG' 162.   253.   163.   76.    1668.   7.9 0.  66.
  1
'Link4'             'AG' 164.   251.   -70.   251.    832.   9.6 0.  66.
  2
'LinkQ1'            'AG' 151.   298.   151.   372.   0.      20.    2
        70        38      3.0   866 173.2   1600 1 3
  2
'LinkQ2'            'AG' 205.   255.   299.   255.   0.      20.    2
        70        38      3.0   832 173.2   1600 1 3
  2
'LinkQ3'            'AG' 172.   203.   172.   122.   0.      20.    2
        70        38      3.0   584 173.2  1600 1 3
  2
'LinkQ4'            'AG' 119.   243.   -14.   244.   0.      20.    2
        70        38      3.0   380 173.2   1600 1 3
1. 0.  4 1000. 5.0 'Y' 10  0 36
```

```
'NB/FR CommRail    2010 Build '        60. 108. 0.   0.   20 0.3048 1 1
'Rec1'               333.      284.      6.
'Rec2'               268.      285.      6.
'Rec3'               199.      286.      6.
'Rec4'               201.      357.      6.
'Rec5'               201.      417.      6.
'Rec6'               333.      207.      6.
'Rec7'               268.      209.      6.
'Rec8'               199.      213.      6.
'Rec9'               203.      141.      6.
'Rec10'              203.      86.       6.
'Rec11'              125.      86.       6.
'Rec12'              125.      148.      6.
'Rec13'              126.      215.      6.
'Rec14'              59.       214.      6.
'Rec15'              -13.      213.      6.
'Rec16'              124.      422.      6.
'Rec17'              125.      355.      6.
'Rec18'              126.      286.      6.
'Rec19'              54.       287.      6.
'Rec20'              -16.      288.      6.
'Foundry St/106 and Rte138 Tpk St'           8  1   1  'C'
  1
'Link1'             'AG' 162.   250.   161.   452.   1382.   7.9 0.  66.
  1
'Link2'             'AG' 161.   250.   369.   247.   1450.   9.6 0.  66.
  1
'Link3'             'AG' 162.   253.   163.   76.    1681.   7.9 0.  66.
  1
'Link4'             'AG' 164.   251.   -70.   251.    827.   9.6 0.  66.
  2
'LinkQ1'            'AG' 151.   298.   151.   372.   0.      20.    2
        70        38     3.0   870 173.2   1600 1 3
  2
'LinkQ2'            'AG' 205.   255.   299.   255.   0.      20.    2
        70        38     3.0   827 173.2   1600 1 3
  2
'LinkQ3'            'AG' 172.   203.   172.   122.   0.      20.    2
        70        38     3.0   593 173.2  1600 1 3
  2
'LinkQ4'            'AG' 119.   243.   -14.   244.   0.      20.    2
        70        38     3.0   380 173.2   1600 1 3
1. 0.  4 1000. 5.0 'Y' 10  0 36
```

```
'NB/FR CommRail 1998 ExistCond'         60. 108. 0.   0.   20 0.3048 1 1
'Rec1'                  333.      284.      6.
'Rec2'                  268.      285.      6.
'Rec3'                  199.      286.      6.
'Rec4'                  201.      357.      6.
'Rec5'                  201.      417.      6.
'Rec6'                  333.      207.      6.
'Rec7'                  268.      209.      6.
'Rec8'                  199.      213.      6.
'Rec9'                  203.      141.      6.
'Rec10'                 203.      86.       6.
'Rec11'                 125.      86.       6.
'Rec12'                 125.      148.      6.
'Rec13'                 126.      215.      6.
'Rec14'                 59.       214.      6.
'Rec15'                 -13.      213.      6.
'Rec16'                 124.      422.      6.
'Rec17'                 125.      355.      6.
'Rec18'                 126.      286.      6.
'Rec19'                 54.       287.      6.
'Rec20'                 -16.      288.      6.
'Torrey/Main St and Rte138 WashSt'           8  1   1  'C'
  1
'Link1'                'AG' 162.   250.   161.   452.   1373.  21.3 0.  66.
  1
'Link2'                'AG' 161.   250.   369.   247.    695.  18.1 0.  42.
  1
'Link3'                'AG' 162.   253.   163.   76.    1369.  21.3 0.  66.
  1
'Link4'                'AG' 164.   251.   -70.   251.    785.  18.1 0.  42.
  2
'LinkQ1'               'AG' 151.   298.   151.   372.   0.      20.    2
       60        28      3.0   793 395.9   1600 1 3
  2
'LinkQ2'               'AG' 205.   255.   299.   255.   0.      10.    1
       60        38      3.0   380 395.9   1600 1 3
  2
'LinkQ3'               'AG' 172.   203.   172.   122.   0.      20.    2
       70        38      3.0   606 395.9  1600 1 3
  2
'LinkQ4'               'AG' 119.   243.   -14.   244.   0.      10.    1
       70        38      3.0   333 395.9   1600 1 3
1. 0.  4 1000. 5.0 'Y' 10  0 36
```

```
'NB/FR CommRail 2010 No Build '         60. 108. 0.   0.   20 0.3048 1 1
'Rec1'               333.      284.      6.
'Rec2'               268.      285.      6.
'Rec3'               199.      286.      6.
'Rec4'               201.      357.      6.
'Rec5'               201.      417.      6.
'Rec6'               333.      207.      6.
'Rec7'               268.      209.      6.
'Rec8'               199.      213.      6.
'Rec9'               203.      141.      6.
'Rec10'              203.      86.       6.
'Rec11'              125.      86.       6.
'Rec12'              125.      148.      6.
'Rec13'              126.      215.      6.
'Rec14'              59.       214.      6.
'Rec15'              -13.      213.      6.
'Rec16'              124.      422.      6.
'Rec17'              125.      355.      6.
'Rec18'              126.      286.      6.
'Rec19'              54.       287.      6.
'Rec20'              -16.      288.      6.
'Torrey/Main St and Rte138 WashSt'           8  1   1  'C'
  1
'Link1'             'AG' 162.   250.   161.   452.   1527.   9.6 0.  66.
  1
'Link2'             'AG' 161.   250.   369.   247.    781.   7.9 0.  42.
  1
'Link3'             'AG' 162.   253.   163.   76.    1523.   9.6 0.  66.
  1
'Link4'             'AG' 164.   251.   -70.   251.    879.   7.9 0.  42.
  2
'LinkQ1'            'AG' 151.   298.   151.   372.   0.      20.    2
        60        28      3.0   874 173.2   1600 1 3
  2
'LinkQ2'            'AG' 205.   255.   299.   255.   0.      10.    1
        60        38      3.0   427 173.2   1600 1 3
  2
'LinkQ3'            'AG' 172.   203.   172.   122.   0.      20.    2
        70        38      3.0   682 173.2  1600 1 3
  2
'LinkQ4'            'AG' 119.   243.   -14.   244.   0.      10.    1
        70        38      3.0   371 173.2   1600 1 3
1. 0.  4 1000. 5.0 'Y' 10  0 36
```

```
'NB/FR CommRail 2010 Build   '         60. 108. 0.   0.   20 0.3048 1 1
'Rec1'               333.      284.      6.
'Rec2'               268.      285.      6.
'Rec3'               199.      286.      6.
'Rec4'               201.      357.      6.
'Rec5'               201.      417.      6.
'Rec6'               333.      207.      6.
'Rec7'               268.      209.      6.
'Rec8'               199.      213.      6.
'Rec9'               203.      141.      6.
'Rec10'              203.      86.       6.
'Rec11'              125.      86.       6.
'Rec12'              125.      148.      6.
'Rec13'              126.      215.      6.
'Rec14'              59.       214.      6.
'Rec15'              -13.      213.      6.
'Rec16'              124.      422.      6.
'Rec17'              125.      355.      6.
'Rec18'              126.      286.      6.
'Rec19'              54.       287.      6.
'Rec20'              -16.      288.      6.
'Torrey/Main St and Rte138 WashSt'           8  1   1  'C'
  1
'Link1'             'AG' 162.   250.   161.   452.   2056.   9.6 0.  66.
  1
'Link2'             'AG' 161.   250.   369.   247.    853.   7.9 0.  42.
  1
'Link3'             'AG' 162.   253.   163.   76.    1804.   9.6 0.  66.
  1
'Link4'             'AG' 164.   251.   -70.   251.   1054.   7.9 0.  42.
  2
'LinkQ1'            'AG' 151.   298.   151.   372.   0.      20.    2
        60        28     3.0  1284 173.2   1600 1 3
  2
'LinkQ2'            'AG' 205.   255.   299.   255.   0.      10.    1
        60        38     3.0   444 173.2   1600 1 3
  2
'LinkQ3'            'AG' 172.   203.   172.   122.   0.      20.    2
        70        38     3.0   746 173.2  1600 1 3
  2
'LinkQ4'            'AG' 119.   243.   -14.   244.   0.      10.    1
        70        38     3.0   409 173.2   1600 1 3
1. 0.  4 1000. 5.0 'Y' 10  0 36
```

CAL3QHC Output Files

```
CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 95221                         PAGE  1

      JOB: NB/FR CommRail 1998 ExistCond                         RUN: Dean Street and Longmeadow Rd

      DATE :  2/ 4/99
      TIME : 15:16: 9

         The MODE flag has been set to C for calculating CO averages.

       SITE & METEOROLOGICAL VARIABLES
       -------------------------------
       VS =     .0 CM/S        VD =     .0 CM/S        Z0 = 108. CM
        U =  1.0 M/S           CLAS =    4  (D)      ATIM =  60. MINUTES     MIXH =  1000. M   AMB =  5.0 PPM

       LINK VARIABLES
       --------------
         LINK DESCRIPTION      *        LINK COORDINATES (FT)           *   LENGTH  BRG TYPE   VPH     EF      H   W   V/C QUEUE
                               *  X1        Y1        X2        Y2      *     (FT)  (DEG)            (G/MI)  (FT) (FT)      (VEH)
      -------------------------*----------------------------------------*-------------------------------------------------------------
       1. Link1                *    162.0     250.0     161.0     452.0 *     202.  360. AG     572.  32.3    .0 66.0
       2. Link2                *    161.0     250.0     369.0     247.0 *     208.   91. AG    2137.  21.3    .0 66.0
       3. Link3                *    162.0     253.0     163.0      76.0 *     177.  180. AG     682.  32.3    .0 66.0
       4. Link4                *    164.0     251.0     -70.0     251.0 *     234.  270. AG    1668.  21.3    .0 66.0
       5. LinkQ1               *    151.0     298.0     151.0     331.5 *      33.  360. AG    1416. 100.0    .0 20.0  .38   1.7
       6. LinkQ2               *    205.0     255.0     238.8     255.0 *      34.   90. AG     513. 100.0    .0 10.0  .31   1.7
       7. LinkQ3               *    172.0     203.0     172.0     176.1 *      27.  180. AG    1416. 100.0    .0 20.0  .31   1.4
       8. LinkQ4               *    119.0     243.0     117.4     243.0 *       2.  270. AG     513. 100.0    .0 10.0  .01    .1
       9. LinkQ5               *    205.0     266.0    5275.2     202.6 *    5071.   91. AG     690. 100.0    .0 10.0 2.11 257.6
      10. LinkQ6               *    118.0     234.0   -4510.0     234.0 *    4628.  270. AG     690. 100.0    .0 10.0 2.01 235.1

       ADDITIONAL QUEUE LINK PARAMETERS
       --------------------------------
         LINK DESCRIPTION      *   CYCLE    RED     CLEARANCE  APPROACH  SATURATION   IDLE   SIGNAL   ARRIVAL
                               *   LENGTH   TIME    LOST TIME    VOL    FLOW RATE  EM FAC   TYPE     RATE
                               *    (SEC)   (SEC)    (SEC)      (VPH)      (VPH)    (gm/hr)
      -------------------------*----------------------------------------------------------------------------------
       5. LinkQ1               *      60       40       3.0       307       1600     395.90     1        3
       6. LinkQ2               *      60       29       3.0       213       1600     395.90     1        3
       7. LinkQ3               *      60       40       3.0       247       1600     395.90     1        3
       8. LinkQ4               *      60       29       3.0        10       1600     395.90     1        3
       9. LinkQ5               *      60       39       3.0       900       1600     395.90     1        3
      10. LinkQ6               *      60       39       3.0       857       1600     395.90     1        3

       RECEPTOR LOCATIONS
       ------------------
                               *          COORDINATES (FT)           *
         RECEPTOR              *      X          Y          Z        *
     --------------------------*-------------------------------------*
      1. Rec1                  *       333.0      284.0        6.0   *
      2. Rec2                  *       268.0      285.0        6.0   *
      3. Rec3                  *       199.0      286.0        6.0   *
      4. Rec4                  *       201.0      357.0        6.0   *
      5. Rec5                  *       201.0      417.0        6.0   *
      6. Rec6                  *       333.0      207.0        6.0   *
      7. Rec7                  *       268.0      209.0        6.0   *
      8. Rec8                  *       199.0      213.0        6.0   *
      9. Rec9                  *       203.0      141.0        6.0   *
     10. Rec10                 *       203.0       86.0        6.0   *
     11. Rec11                 *       125.0       86.0        6.0   *
     12. Rec12                 *       125.0      148.0        6.0   *
     13. Rec13                 *       126.0      215.0        6.0   *
     14. Rec14                 *        59.0      214.0        6.0   *
     15. Rec15                 *       -13.0      213.0        6.0   *
     16. Rec16                 *       124.0      422.0        6.0   *
     17. Rec17                 *       125.0      355.0        6.0   *
     18. Rec18                 *       126.0      286.0        6.0   *
     19. Rec19                 *        54.0      287.0        6.0   *
     20. Rec20                 *       -16.0      288.0        6.0   *
```

```
JOB: NB/FR CommRail 1998 ExistCond                    RUN: Dean Street and Longmeadow Rd

 MODEL RESULTS
 -------------

 REMARKS : In search of the angle corresponding to
           the maximum concentration, only the first
           angle, of the angles with same maximum
           concentrations, is indicated as maximum.

WIND ANGLE RANGE:   0.-360.

WIND   * CONCENTRATION
ANGLE  *      (PPM)
(DEGR)* REC1  REC2  REC3  REC4  REC5  REC6  REC7  REC8  REC9  REC10 REC11 REC12 REC13 REC14 REC15 REC16 REC17 REC18 REC19 REC20
------*------------------------------------------------------------------------------------------------------------------------
  0.  *   5.0   5.0   5.4   5.2   5.0   7.1   7.1   7.3   6.8   6.7   6.5   6.6   7.2   7.5   7.5   5.1   5.3   5.6   5.0   5.0
 10.  *   5.0   5.0   5.2   5.1   5.0   7.0   7.0   7.3   6.5   6.2   7.0   7.0   7.5   7.6   7.5   5.1   5.4   6.3   5.0   5.0
 20.  *   5.0   5.0   5.1   5.0   5.0   6.9   7.0   7.4   6.3   6.1   7.3   7.3   7.6   7.7   7.3   5.2   5.5   7.3   5.1   5.0
 30.  *   5.0   5.0   5.0   5.0   5.0   6.9   7.1   7.7   6.3   5.9   7.3   7.7   7.4   8.1   7.6   5.2   5.6   8.0   5.2   5.0
 40.  *   5.0   5.1   5.1   5.0   5.0   6.7   7.2   7.8   6.3   5.9   7.0   8.1   7.4   8.5   7.9   5.3   5.6   8.3   5.3   5.2
 50.  *   5.0   5.1   5.1   5.0   5.0   6.7   7.4   7.8   6.2   5.7   6.7   8.3   7.6   8.9   8.4   5.3   5.6   8.2   5.6   5.2
 60.  *   5.0   5.1   5.1   5.0   5.0   6.6   7.4   7.8   6.1   5.6   6.3   8.1   8.2   8.9   8.7   5.4   5.5   7.6   5.9   5.4
 70.  *   5.2   5.3   5.4   5.0   5.0   6.6   7.4   7.9   6.0   5.6   6.3   7.4   8.8   9.1   9.1   5.5   5.5   7.3   6.3   5.7
 80.  *   6.1   6.3   6.4   5.2   5.1   6.7   7.3   8.0   5.9   5.7   6.3   6.9   9.0   9.2   9.3   5.6   5.7   7.6   7.2   6.6
 90.  *   7.4   7.9   8.1   5.8   5.5   6.2   6.7   7.2   5.6   5.5   6.0   6.3   8.5   8.3   8.2   6.0   6.3   8.8   8.4   7.9
100.  *   8.0   8.6   9.0   6.1   5.8   5.4   5.7   6.0   5.2   5.1   5.5   5.8   7.5   6.9   6.7   6.2   6.8   9.0   8.4   8.2
110.  *   7.9   8.7   9.2   6.2   5.7   5.1   5.2   5.3   5.0   5.0   5.3   5.6   7.2   6.1   5.7   6.3   7.2   8.5   7.9   7.9
120.  *   7.8   8.4   8.9   6.2   5.7   5.0   5.1   5.1   5.0   5.0   5.2   5.6   7.1   5.6   5.4   6.3   7.8   7.8   7.7   7.7
130.  *   7.6   8.3   8.9   6.3   5.8   5.0   5.1   5.1   5.0   5.0   5.1   5.6   6.9   5.5   5.2   6.5   8.4   7.6   7.5   7.4
140.  *   7.6   8.1   8.6   6.4   5.9   5.0   5.1   5.1   5.0   5.0   5.1   5.6   6.4   5.3   5.1   6.7   9.0   7.5   7.4   7.1
150.  *   7.7   7.9   8.2   6.4   6.0   5.0   5.0   5.2   5.0   5.0   5.1   5.5   6.1   5.1   5.0   7.1   9.0   7.7   7.2   7.0
160.  *   7.7   7.7   7.7   6.5   6.0   5.0   5.0   5.1   5.0   5.0   5.0   5.5   5.8   5.1   5.0   7.3   8.5   7.5   6.8   6.8
170.  *   7.8   7.7   7.5   6.6   6.2   5.0   5.0   5.2   5.1   5.0   5.0   5.4   5.6   5.0   5.0   7.2   7.6   7.2   6.8   6.8
180.  *   7.8   7.8   7.7   6.7   6.6   5.0   5.0   5.5   5.2   5.0   5.0   5.2   5.4   5.0   5.0   6.7   6.8   6.9   7.0   6.9
190.  *   7.8   7.8   7.9   6.8   7.1   5.0   5.0   5.9   5.3   5.0   5.0   5.1   5.2   5.0   5.0   6.2   6.2   6.7   6.9   6.8
200.  *   7.7   8.0   7.7   7.0   7.2   5.0   5.0   6.5   5.4   5.0   5.0   5.1   5.1   5.0   5.0   5.9   6.2   6.7   6.8   6.9
210.  *   8.0   8.6   7.6   7.4   7.2   5.0   5.1   7.3   5.5   5.1   5.0   5.0   5.1   5.0   5.0   5.8   6.1   6.8   6.9   6.9
220.  *   8.2   9.1   7.5   7.9   6.8   5.0   5.2   7.9   5.5   5.1   5.0   5.0   5.1   5.1   5.0   5.7   6.1   7.0   7.0   6.8
230.  *   8.7   9.6   7.5   8.2   6.6   5.2   5.5   8.1   5.6   5.1   5.0   5.0   5.1   5.1   5.0   5.7   6.1   7.2   7.2   6.8
240.  *   9.3   9.8   7.9   7.9   6.2   5.4   5.7   7.9   5.6   5.2   5.0   5.0   5.1   5.1   5.0   5.6   6.1   7.4   7.3   6.8
250.  *   9.8   9.6   8.3   7.4   6.2   5.6   6.1   7.6   5.6   5.2   5.0   5.0   5.4   5.3   5.3   5.6   6.0   7.7   7.4   6.9
260.  *   9.9   9.3   8.5   6.8   6.2   6.4   7.1   7.8   5.8   5.5   5.1   5.3   6.5   6.3   6.1   5.6   6.0   7.8   7.5   6.9
270.  *   8.9   8.4   8.2   6.2   5.9   7.6   8.0   8.7   6.4   6.0   5.5   5.8   8.1   7.8   7.4   5.4   5.6   7.1   6.8   6.4
280.  *   6.9   6.9   7.4   5.7   5.6   8.4   8.2   8.8   6.7   6.3   5.8   6.2   8.9   8.5   8.0   5.1   5.2   5.8   5.7   5.5
290.  *   5.8   6.3   7.2   5.5   5.5   8.1   7.9   8.1   6.9   6.4   5.7   6.2   8.8   8.4   7.8   5.0   5.0   5.3   5.2   5.2
300.  *   5.4   5.7   7.2   5.5   5.4   8.1   7.9   7.5   7.2   6.4   5.7   6.2   8.4   8.2   7.7   5.0   5.0   5.1   5.1   5.1
310.  *   5.2   5.5   7.0   5.5   5.3   7.8   8.0   7.5   7.6   6.6   5.8   6.3   7.9   8.0   7.6   5.0   5.0   5.1   5.1   5.0
320.  *   5.2   5.3   6.5   5.6   5.3   7.6   8.2   7.6   8.1   6.7   5.8   6.2   7.5   7.7   7.5   5.0   5.0   5.1   5.1   5.1
330.  *   5.1   5.3   6.0   5.5   5.2   7.3   7.8   7.8   8.2   7.0   5.9   6.3   7.0   7.6   7.5   5.0   5.0   5.2   5.0   5.0
340.  *   5.0   5.1   5.8   5.4   5.2   7.0   7.3   7.7   8.0   7.3   5.9   6.3   6.8   7.4   7.3   5.0   5.1   5.1   5.0   5.0
350.  *   5.0   5.0   5.6   5.3   5.1   7.0   7.1   7.6   7.4   7.2   6.1   6.2   7.0   7.5   7.5   5.0   5.1   5.2   5.0   5.0
360.  *   5.0   5.0   5.4   5.2   5.0   7.1   7.1   7.3   6.8   6.7   6.5   6.6   7.2   7.5   7.5   5.1   5.3   5.6   5.0   5.0
------*------------------------------------------------------------------------------------------------------------------------
MAX   *   9.9   9.8   9.2   8.2   7.2   8.4   8.2   8.8   8.2   7.3   7.3   8.3   9.0   9.2   9.3   7.3   9.0   9.0   8.4   8.2
DEGR. *   260   240   110   230   200   280   320   280   330   340    20    50    80    80    80   160   140   100    90   100

THE HIGHEST CONCENTRATION OF    9.90 PPM OCCURRED AT RECEPTOR REC1 .
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CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 95221                    PAGE  1

     JOB: NB/FR CommRail 2010 No Build                    RUN: Dean Street and Longmeadow Rd

     DATE :  2/ 4/99
     TIME : 15:17: 1

        The MODE flag has been set to C for calculating CO averages.

      SITE & METEOROLOGICAL VARIABLES
      -------------------------------
      V$ =    .0 CM/S        VD =     .0 CM/S       Z0 = 108. CM
       U =  1.0 M/S          CLAS =   4  (D)      ATIM =  60. MINUTES     MIXH =  1000. M   AMB =  5.0 PPM

      LINK VARIABLES
      --------------
        LINK DESCRIPTION     *         LINK COORDINATES (FT)            *   LENGTH  BRG TYPE  VPH    EF      H   W    V/C QUEUE
                             *   X1        Y1        X2        Y2       *    (FT)  (DEG)            (G/MI)  (FT) (FT)       (VEH)
     ------------------------*------------------------------------------*------------------------------------------------------------
      1. Link1               *   162.0     250.0     161.0     452.0 *     202.   360. AG    648.  15.7    .0 66.0
      2. Link2               *   161.0     250.0     369.0     247.0 *     208.    91. AG   2410.   9.6    .0 66.0
      3. Link3               *   162.0     253.0     163.0      76.0 *     177.   180. AG    768.  15.7    .0 66.0
      4. Link4               *   164.0     251.0     -70.0     251.0 *     234.   270. AG   1881.   9.6    .0 66.0
      5. LinkQ1              *   151.0     298.0     151.0     336.3 *      38.   360. AG    619. 100.0    .0 20.0  .44    1.9
      6. LinkQ2              *   205.0     255.0     242.9     255.0 *      38.    90. AG    225. 100.0    .0 10.0  .34    1.9
      7. LinkQ3              *   172.0     203.0     172.0     172.8 *      30.   180. AG    619. 100.0    .0 20.0  .35    1.5
      8. LinkQ4              *   119.0     243.0     117.4     243.0 *       2.   270. AG    225. 100.0    .0 10.0  .01     .1
      9. LinkQ5              *   205.0     266.0    6458.8     187.8 *    6254.    91. AG    302. 100.0    .0 10.0 2.38 317.7
     10. LinkQ6              *   118.0     234.0   -5652.5     234.0 *    5771.   270. AG    302. 100.0    .0 10.0 2.27 293.1

      ADDITIONAL QUEUE LINK PARAMETERS
      --------------------------------
        LINK DESCRIPTION     *   CYCLE    RED    CLEARANCE  APPROACH  SATURATION   IDLE   SIGNAL   ARRIVAL
                             *   LENGTH   TIME   LOST TIME    VOL     FLOW RATE   EM FAC   TYPE     RATE
                             *   (SEC)   (SEC)     (SEC)     (VPH)      (VPH)    (gm/hr)
     ------------------------*---------------------------------------------------------------------------
      5. LinkQ1              *     60      40       3.0       350       1600     173.20      1         3
      6. LinkQ2              *     60      29       3.0       239       1600     173.20      1         3
      7. LinkQ3              *     60      40       3.0       277       1600     173.20      1         3
      8. LinkQ4              *     60      29       3.0        10       1600     173.20      1         3
      9. LinkQ5              *     60      39       3.0      1015       1600     173.20      1         3
     10. LinkQ6              *     60      39       3.0       968       1600     173.20      1         3

      RECEPTOR LOCATIONS
      ------------------
                             *           COORDINATES (FT)            *
        RECEPTOR             *       X            Y           Z      *
     ------------------------*-----------------------------------*
      1. Rec1                *       333.0        284.0         6.0    *
      2. Rec2                *       268.0        285.0         6.0    *
      3. Rec3                *       199.0        286.0         6.0    *
      4. Rec4                *       201.0        357.0         6.0    *
      5. Rec5                *       201.0        417.0         6.0    *
      6. Rec6                *       333.0        207.0         6.0    *
      7. Rec7                *       268.0        209.0         6.0    *
      8. Rec8                *       199.0        213.0         6.0    *
      9. Rec9                *       203.0        141.0         6.0    *
     10. Rec10               *       203.0         86.0         6.0    *
     11. Rec11               *       125.0         86.0         6.0    *
     12. Rec12               *       125.0        148.0         6.0    *
     13. Rec13               *       126.0        215.0         6.0    *
     14. Rec14               *        59.0        214.0         6.0    *
     15. Rec15               *       -13.0        213.0         6.0    *
     16. Rec16               *       124.0        422.0         6.0    *
     17. Rec17               *       125.0        355.0         6.0    *
     18. Rec18               *       126.0        286.0         6.0    *
     19. Rec19               *        54.0        287.0         6.0    *
     20. Rec20               *       -16.0        288.0         6.0    *
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       MODEL RESULTS
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       REMARKS : In search of the angle corresponding to
                 the maximum concentration, only the first
                 angle, of the angles with same maximum
                 concentrations, is indicated as maximum.

  WIND ANGLE RANGE:    0.-360.

  WIND   * CONCENTRATION
  ANGLE  *       (PPM)
  (DEGR) * REC1   REC2   REC3   REC4   REC5   REC6   REC7   REC8   REC9   REC10  REC11  REC12  REC13  REC14  REC15  REC16  REC17  REC18  REC19  REC20
  -------*-----------------------------------------------------------------------------------------------------------------------------------------------
    0.   *   5.0    5.0    5.2    5.1    5.0    6.0    6.1    6.3    5.9    5.8    5.8    5.9    6.1    6.2    6.1    5.0    5.2    5.3    5.0    5.0
   10.   *   5.0    5.0    5.1    5.0    5.0    6.0    6.0    6.1    5.7    5.6    6.0    6.0    6.3    6.2    6.1    5.1    5.2    5.7    5.0    5.0
   20.   *   5.0    5.0    5.0    5.0    5.0    6.0    6.0    6.1    5.7    5.5    6.3    5.9    6.5    6.3    6.1    5.1    5.3    6.2    5.0    5.0
   30.   *   5.0    5.0    5.0    5.0    5.0    5.9    6.0    6.4    5.6    5.4    6.0    6.4    6.2    6.5    6.2    5.1    5.3    6.5    5.1    5.0
   40.   *   5.0    5.0    5.0    5.0    5.0    5.8    6.1    6.3    5.5    5.4    6.1    6.5    6.3    6.7    6.5    5.1    5.3    6.5    5.1    5.0
   50.   *   5.0    5.1    5.1    5.0    5.0    5.7    6.1    6.3    5.6    5.3    5.9    6.7    6.3    6.7    6.6    5.2    5.3    6.5    5.2    5.1
   60.   *   5.0    5.1    5.1    5.0    5.0    5.8    6.2    6.4    5.5    5.2    5.6    6.4    6.7    6.9    6.8    5.2    5.3    6.2    5.5    5.2
   70.   *   5.1    5.2    5.2    5.0    5.0    5.7    6.1    6.4    5.4    5.3    5.6    6.1    6.8    6.8    7.0    5.3    5.3    6.1    5.8    5.3
   80.   *   5.4    5.5    5.6    5.1    5.1    5.7    6.1    6.3    5.4    5.3    5.6    5.9    7.0    6.9    7.0    5.4    5.4    6.3    6.0    5.8
   90.   *   6.1    6.3    6.5    5.3    5.2    5.6    5.8    6.0    5.3    5.2    5.5    5.7    6.8    6.6    6.4    5.5    5.7    6.8    6.5    6.3
  100.   *   6.4    6.7    6.9    5.5    5.3    5.2    5.3    5.4    5.1    5.1    5.3    5.4    6.1    5.8    5.7    5.6    6.0    7.0    6.8    6.6
  110.   *   6.3    6.6    6.9    5.5    5.3    5.0    5.0    5.1    5.0    5.0    5.1    5.3    6.0    5.5    5.3    5.6    6.2    6.8    6.3    6.4
  120.   *   6.2    6.6    6.9    5.6    5.3    5.0    5.0    5.1    5.0    5.0    5.1    5.3    6.0    5.3    5.1    5.7    6.4    6.4    6.1    6.2
  130.   *   6.2    6.6    6.9    5.6    5.3    5.0    5.0    5.1    5.0    5.0    5.1    5.3    6.0    5.2    5.1    5.7    6.8    6.3    6.3    6.2
  140.   *   6.2    6.4    6.7    5.6    5.4    5.0    5.0    5.0    5.0    5.0    5.1    5.3    5.8    5.1    5.0    5.8    6.9    6.3    6.2    6.1
  150.   *   6.2    6.4    6.5    5.8    5.4    5.0    5.0    5.0    5.0    5.0    5.0    5.3    5.6    5.1    5.0    5.9    7.1    6.5    6.1    5.9
  160.   *   6.3    6.3    6.3    5.8    5.5    5.0    5.0    5.0    5.0    5.0    5.0    5.3    5.4    5.0    5.0    6.3    6.7    6.3    6.0    5.9
  170.   *   6.4    6.3    6.2    5.7    5.5    5.0    5.0    5.1    5.0    5.0    5.0    5.2    5.3    5.0    5.0    6.0    6.2    6.1    5.9    5.9
  180.   *   6.4    6.4    6.4    5.8    5.8    5.0    5.0    5.2    5.1    5.0    5.0    5.1    5.2    5.0    5.0    5.9    5.9    6.0    5.9    5.9
  190.   *   6.3    6.3    6.4    6.0    6.0    5.0    5.0    5.5    5.2    5.0    5.0    5.1    5.1    5.0    5.0    5.5    5.7    5.8    5.9    5.9
  200.   *   6.3    6.4    6.3    6.0    6.1    5.0    5.0    5.8    5.2    5.0    5.0    5.0    5.0    5.0    5.0    5.4    5.5    5.8    5.9    5.9
  210.   *   6.4    6.6    6.3    6.1    5.9    5.0    5.1    6.2    5.2    5.0    5.0    5.0    5.0    5.0    5.0    5.4    5.5    5.9    5.9    5.9
  220.   *   6.5    7.0    6.3    6.3    5.9    5.0    5.1    6.4    5.3    5.0    5.0    5.0    5.0    5.0    5.0    5.4    5.6    6.0    6.0    5.9
  230.   *   6.8    7.3    6.2    6.5    5.8    5.1    5.3    6.5    5.3    5.1    5.0    5.0    5.0    5.0    5.0    5.3    5.6    6.1    6.0    5.8
  240.   *   7.1    7.1    6.4    6.5    5.6    5.1    5.4    6.3    5.3    5.1    5.0    5.0    5.1    5.0    5.0    5.2    5.5    6.2    6.1    5.9
  250.   *   7.2    7.3    6.6    6.2    5.6    5.3    5.6    6.1    5.3    5.1    5.0    5.0    5.2    5.2    5.1    5.3    5.4    6.3    6.2    5.9
  260.   *   7.3    7.1    6.7    6.0    5.6    5.7    6.0    6.2    5.4    5.3    5.1    5.1    5.7    5.6    5.5    5.3    5.4    6.3    6.1    5.8
  270.   *   6.8    6.6    6.5    5.7    5.5    6.2    6.5    6.8    5.6    5.5    5.2    5.4    6.4    6.3    6.1    5.2    5.3    6.0    5.8    5.7
  280.   *   5.9    6.0    6.2    5.4    5.3    6.6    6.6    6.7    5.9    5.6    5.3    5.5    6.8    6.6    6.3    5.0    5.1    5.4    5.4    5.3
  290.   *   5.3    5.6    6.1    5.3    5.3    6.6    6.5    6.5    6.0    5.6    5.3    5.5    6.7    6.6    6.3    5.0    5.0    5.1    5.1    5.0
  300.   *   5.3    5.5    6.1    5.3    5.2    6.5    6.5    6.3    6.1    5.7    5.4    5.6    6.6    6.5    6.3    5.0    5.0    5.1    5.0    5.0
  310.   *   5.2    5.4    6.0    5.3    5.2    6.3    6.5    6.2    6.4    5.8    5.3    5.6    6.4    6.4    6.2    5.0    5.0    5.0    5.0    5.0
  320.   *   5.0    5.1    5.8    5.3    5.1    6.2    6.6    6.3    6.4    5.9    5.4    5.6    6.2    6.3    6.2    5.0    5.0    5.0    5.0    5.0
  330.   *   5.0    5.1    5.7    5.3    5.1    6.0    6.3    6.4    6.7    5.9    5.4    5.6    6.0    6.2    6.2    5.0    5.0    5.0    5.0    5.0
  340.   *   5.0    5.0    5.5    5.2    5.1    6.0    6.2    6.5    6.4    6.1    5.4    5.5    5.8    6.1    6.1    5.0    5.0    5.0    5.0    5.0
  350.   *   5.0    5.0    5.3    5.2    5.1    6.0    6.0    6.3    6.2    6.1    5.5    5.8    5.9    6.2    6.1    5.0    5.1    5.1    5.0    5.0
  360.   *   5.0    5.0    5.2    5.1    5.0    6.0    6.1    6.3    5.9    5.8    5.8    5.9    6.1    6.2    6.1    5.0    5.2    5.3    5.0    5.0
  -------*-----------------------------------------------------------------------------------------------------------------------------------------------
  MAX    *   7.3    7.3    6.9    6.5    6.1    6.6    6.6    6.8    6.7    6.1    6.3    6.7    7.0    6.9    7.0    6.3    7.1    7.0    6.8    6.6
  DEGR.  *   260    230    100    230    200    290    320    270    330    340    20     50     80     60     70     160    150    100    100    100

  THE HIGHEST CONCENTRATION OF     7.30 PPM OCCURRED AT RECEPTOR REC2 .
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CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 95221                      PAGE  1

     JOB: NB/FR CommRail    2010 Build                            RUN: Dean Street and Longmeadow Rd

     DATE :  2/ 4/99
     TIME : 15:17:32

        The MODE flag has been set to C for calculating CO averages.

      SITE & METEOROLOGICAL VARIABLES
      -------------------------------
      VS =    .0 CM/S       VD =    .0 CM/S       Z0 = 108. CM
       U =  1.0 M/S         CLAS =   4  (D)     ATIM =  60. MINUTES      MIXH =  1000. M   AMB =  5.0 PPM

      LINK VARIABLES
      --------------
        LINK DESCRIPTION      *        LINK COORDINATES (FT)             *   LENGTH  BRG TYPE  VPH    EF      H   W    V/C QUEUE
                              *   X1        Y1        X2        Y2       *    (FT)  (DEG)             (G/MI)  (FT) (FT)       (VEH)
     -------------------------*------------------------------------------*------------------------------------------------------------
      1. Link1                *   162.0     250.0     161.0     452.0 *    202.   360. AG    648.  15.7    .0 66.0
      2. Link2                *   161.0     250.0     369.0     247.0 *    208.    91. AG   2435.   9.6    .0 66.0
      3. Link3                *   162.0     253.0     163.0      76.0 *    177.   180. AG    768.  15.7    .0 66.0
      4. Link4                *   164.0     251.0     -70.0     251.0 *    234.   270. AG   1907.   9.6    .0 66.0
      5. LinkQ1               *   151.0     298.0     151.0     336.3 *     38.   360. AG    619. 100.0    .0 20.0  .44    1.9
      6. LinkQ2               *   205.0     255.0     242.9     255.0 *     38.    90. AG    225. 100.0    .0 10.0  .34    1.9
      7. LinkQ3               *   172.0     203.0     172.0     172.8 *     30.   180. AG    619. 100.0    .0 20.0  .35    1.5
      8. LinkQ4               *   119.0     243.0     117.4     243.0 *      2.   270. AG    225. 100.0    .0 10.0  .01     .1
      9. LinkQ5               *   205.0     266.0    8959.8     156.6 *   8755.    91. AG    302. 100.0    .0 10.0 2.95 444.8
     10. LinkQ6               *   118.0     234.0   -5920.2     234.0 *   6038.   270. AG    302. 100.0    .0 10.0 2.33 306.7

      ADDITIONAL QUEUE LINK PARAMETERS
      --------------------------------
        LINK DESCRIPTION      *    CYCLE    RED    CLEARANCE  APPROACH  SATURATION   IDLE   SIGNAL   ARRIVAL
                              *    LENGTH   TIME   LOST TIME    VOL     FLOW RATE   EM FAC   TYPE     RATE
                              *    (SEC)   (SEC)    (SEC)      (VPH)      (VPH)     (gm/hr)
     -------------------------*------------------------------------------------------------------------------
      5. LinkQ1               *      60      40      3.0        350       1600     173.20      1        3
      6. LinkQ2               *      60      29      3.0        239       1600     173.20      1        3
      7. LinkQ3               *      60      40      3.0        277       1600     173.20      1        3
      8. LinkQ4               *      60      29      3.0         10       1600     173.20      1        3
      9. LinkQ5               *      60      39      3.0       1258       1600     173.20      1        3
     10. LinkQ6               *      60      39      3.0        994       1600     173.20      1        3

      RECEPTOR LOCATIONS
      ------------------
                              *        COORDINATES (FT)        *
        RECEPTOR              *      X          Y          Z   *
     -------------------------*--------------------------------*
      1. Rec1                 *     333.0      284.0       6.0   *
      2. Rec2                 *     268.0      285.0       6.0   *
      3. Rec3                 *     199.0      286.0       6.0   *
      4. Rec4                 *     201.0      357.0       6.0   *
      5. Rec5                 *     201.0      417.0       6.0   *
      6. Rec6                 *     333.0      207.0       6.0   *
      7. Rec7                 *     268.0      209.0       6.0   *
      8. Rec8                 *     199.0      213.0       6.0   *
      9. Rec9                 *     203.0      141.0       6.0   *
     10. Rec10                *     203.0       86.0       6.0   *
     11. Rec11                *     125.0       86.0       6.0   *
     12. Rec12                *     125.0      148.0       6.0   *
     13. Rec13                *     126.0      215.0       6.0   *
     14. Rec14                *      59.0      214.0       6.0   *
     15. Rec15                *     -13.0      213.0       6.0   *
     16. Rec16                *     124.0      422.0       6.0   *
     17. Rec17                *     125.0      355.0       6.0   *
     18. Rec18                *     126.0      286.0       6.0   *
     19. Rec19                *      54.0      287.0       6.0   *
     20. Rec20                *     -16.0      288.0       6.0   *
```

```
    MODEL RESULTS
    -------------

    REMARKS : In search of the angle corresponding to
              the maximum concentration, only the first
              angle, of the angles with same maximum
              concentrations, is indicated as maximum.

WIND ANGLE RANGE:   0.-360.

WIND   * CONCENTRATION
ANGLE  *      (PPM)
(DEGR)* REC1  REC2  REC3  REC4  REC5  REC6  REC7  REC8  REC9  REC10 REC11 REC12 REC13 REC14 REC15 REC16 REC17 REC18 REC19 REC20
------*----------------------------------------------------------------------------------------------------------------------------
  0.  *   5.0   5.0   5.2   5.1   5.0   6.0   6.1   6.3   5.9   5.8   5.8   5.9   6.1   6.2   6.1   5.0   5.2   5.3   5.0   5.0
 10.  *   5.0   5.0   5.1   5.0   5.0   6.0   6.0   6.2   5.7   5.6   6.0   6.0   6.3   6.2   6.1   5.1   5.2   5.7   5.0   5.0
 20.  *   5.0   5.0   5.0   5.0   5.0   6.0   6.0   6.1   5.7   5.5   6.3   6.0   6.5   6.3   6.1   5.1   5.3   6.2   5.0   5.0
 30.  *   5.0   5.0   5.0   5.0   5.0   5.9   6.0   6.4   5.6   5.4   6.0   6.4   6.3   6.5   6.2   5.1   5.3   6.5   5.1   5.0
 40.  *   5.0   5.0   5.0   5.0   5.0   5.8   6.1   6.3   5.5   5.4   6.1   6.5   6.3   6.7   6.5   5.1   5.3   6.5   5.1   5.0
 50.  *   5.0   5.1   5.1   5.0   5.0   5.7   6.1   6.3   5.6   5.3   5.9   6.7   6.3   6.7   6.6   5.2   5.3   6.5   5.2   5.1
 60.  *   5.0   5.1   5.1   5.0   5.0   5.8   6.2   6.4   5.5   5.2   5.6   6.4   6.7   6.9   6.8   5.2   5.3   6.2   5.5   5.2
 70.  *   5.1   5.2   5.2   5.0   5.0   5.7   6.1   6.4   5.4   5.3   5.6   6.1   6.8   6.8   7.0   5.3   5.3   6.1   5.8   5.3
 80.  *   5.4   5.6   5.6   5.1   5.1   5.7   6.1   6.5   5.4   5.3   5.6   5.9   7.0   6.9   7.1   5.4   5.4   6.3   6.0   5.8
 90.  *   6.1   6.3   6.5   5.4   5.2   5.6   5.8   6.1   5.3   5.2   5.5   5.7   6.8   6.6   6.6   5.5   5.7   6.8   6.5   6.3
100.  *   6.4   6.7   6.9   5.5   5.4   5.2   5.3   5.4   5.1   5.1   5.3   5.4   6.1   5.8   5.8   5.6   6.0   7.0   6.8   6.7
110.  *   6.3   6.7   6.9   5.5   5.3   5.0   5.0   5.1   5.0   5.0   5.1   5.3   6.0   5.5   5.3   5.6   6.2   6.8   6.4   6.4
120.  *   6.2   6.6   6.9   5.6   5.3   5.0   5.0   5.1   5.0   5.0   5.1   5.3   6.0   5.3   5.1   5.7   6.4   6.4   6.1   6.3
130.  *   6.2   6.6   6.9   5.6   5.3   5.0   5.0   5.1   5.0   5.0   5.1   5.3   6.0   5.2   5.1   5.7   6.8   6.3   6.3   6.2
140.  *   6.2   6.4   6.7   5.6   5.4   5.0   5.0   5.0   5.0   5.0   5.1   5.3   5.8   5.1   5.0   5.8   6.9   6.3   6.2   6.1
150.  *   6.3   6.4   6.5   5.8   5.4   5.0   5.0   5.0   5.0   5.0   5.0   5.3   5.6   5.1   5.0   5.9   7.1   6.5   6.1   5.9
160.  *   6.3   6.3   6.3   5.8   5.5   5.0   5.0   5.0   5.0   5.0   5.0   5.3   5.4   5.0   5.0   6.3   6.7   6.3   6.0   5.9
170.  *   6.4   6.3   6.2   5.7   5.6   5.0   5.0   5.1   5.0   5.0   5.0   5.2   5.3   5.0   5.0   6.0   6.2   6.1   5.9   5.9
180.  *   6.4   6.4   6.4   5.8   5.8   5.0   5.0   5.2   5.1   5.0   5.0   5.1   5.2   5.0   5.0   5.9   5.9   6.1   5.9   5.9
190.  *   6.4   6.3   6.4   6.0   6.0   5.0   5.0   5.5   5.2   5.0   5.0   5.1   5.1   5.0   5.0   5.5   5.7   5.8   5.9   5.9
200.  *   6.3   6.4   6.4   6.0   6.1   5.0   5.0   5.8   5.2   5.0   5.0   5.0   5.0   5.0   5.0   5.4   5.5   5.8   5.9   5.9
210.  *   6.4   6.7   6.3   6.1   5.9   5.0   5.1   6.2   5.2   5.0   5.0   5.0   5.0   5.0   5.0   5.4   5.5   5.9   5.9   5.9
220.  *   6.5   7.0   6.3   6.3   5.9   5.0   5.1   6.4   5.3   5.0   5.0   5.0   5.0   5.0   5.0   5.4   5.6   6.0   6.0   5.9
230.  *   6.8   7.3   6.2   6.5   5.8   5.1   5.3   6.5   5.3   5.1   5.0   5.0   5.0   5.0   5.0   5.3   5.6   6.1   6.0   5.8
240.  *   7.1   7.2   6.4   6.5   5.6   5.1   5.4   6.3   5.3   5.1   5.0   5.0   5.1   5.0   5.0   5.2   5.5   6.2   6.1   5.9
250.  *   7.2   7.3   6.6   6.2   5.6   5.3   5.6   6.1   5.3   5.1   5.0   5.0   5.2   5.2   5.1   5.3   5.4   6.3   6.2   5.9
260.  *   7.4   7.1   6.7   6.0   5.6   5.7   6.0   6.3   5.4   5.3   5.1   5.1   5.7   5.6   5.5   5.3   5.4   6.4   6.1   5.9
270.  *   6.8   6.6   6.5   5.7   5.5   6.2   6.5   6.8   5.7   5.5   5.2   5.4   6.4   6.3   6.1   5.2   5.3   6.0   5.8   5.7
280.  *   5.9   6.0   6.2   5.4   5.3   6.6   6.6   6.7   5.9   5.6   5.3   5.5   6.8   6.6   6.3   5.0   5.1   5.4   5.4   5.3
290.  *   5.3   5.6   6.1   5.3   5.3   6.6   6.5   6.5   6.0   5.6   5.3   5.5   6.7   6.6   6.3   5.0   5.0   5.1   5.1   5.0
300.  *   5.3   5.5   6.1   5.3   5.2   6.5   6.5   6.4   6.1   5.7   5.4   5.6   6.6   6.5   6.3   5.0   5.0   5.1   5.0   5.0
310.  *   5.2   5.4   6.0   5.3   5.2   6.3   6.5   6.3   6.4   5.8   5.3   5.6   6.4   6.4   6.2   5.0   5.0   5.0   5.0   5.0
320.  *   5.0   5.1   5.8   5.3   5.1   6.2   6.6   6.4   6.4   5.9   5.4   5.6   6.2   6.3   6.2   5.0   5.0   5.0   5.0   5.0
330.  *   5.0   5.1   5.7   5.3   5.1   6.1   6.3   6.4   6.7   5.9   5.4   5.6   6.0   6.2   6.2   5.0   5.0   5.0   5.0   5.0
340.  *   5.0   5.0   5.5   5.2   5.1   6.0   6.2   6.5   6.4   6.1   5.4   5.5   5.8   6.1   6.1   5.0   5.0   5.0   5.0   5.0
350.  *   5.0   5.0   5.3   5.2   5.1   6.0   6.0   6.3   6.2   6.1   5.5   5.8   5.9   6.2   6.1   5.0   5.1   5.1   5.0   5.0
360.  *   5.0   5.0   5.2   5.1   5.0   6.0   6.1   6.3   5.9   5.8   5.8   5.9   6.1   6.2   6.1   5.0   5.2   5.3   5.0   5.0
------*----------------------------------------------------------------------------------------------------------------------------
MAX   *   7.4   7.3   6.9   6.5   6.1   6.6   6.6   6.8   6.7   6.1   6.3   6.7   7.0   6.9   7.1   6.3   7.1   7.0   6.8   6.7
DEGR. *   260   230   100   230   200   290   320   270   330   340    20    50    80    60    80   160   150   100   100   100

THE HIGHEST CONCENTRATION OF    7.40 PPM OCCURRED AT RECEPTOR REC1 .
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CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 95221                      PAGE  1

      JOB: NB/FR CommRail 1998 ExistCond                           RUN: Foundry St/Rt106 and Rte138 TpkSt

      DATE :  2/ 4/99
      TIME : 15:18:33

         The MODE flag has been set to C for calculating CO averages.

       SITE & METEOROLOGICAL VARIABLES
       -------------------------------
       VS =    .0 CM/S       VD =    .0 CM/S       Z0 = 108. CM
        U =  1.0 M/S         CLAS =    4  (D)    ATIM =  60. MINUTES     MIXH =  1000. M   AMB =  5.0 PPM

       LINK VARIABLES
       --------------
         LINK DESCRIPTION     *        LINK COORDINATES (FT)              *    LENGTH  BRG TYPE  VPH    EF      H   W    V/C QUEUE
                              *  X1         Y1         X2         Y2      *     (FT)  (DEG)            (G/MI)  (FT) (FT)        (VEH)
      ------------------------*-------------------------------------------*-------------------------------------------------------------
       1. Link1               *   162.0      250.0      161.0      452.0 *     202.   360. AG  1211.  18.1    .0 66.0
       2. Link2               *   161.0      250.0      369.0      247.0 *     208.    91. AG  1288.  21.3    .0 66.0
       3. Link3               *   162.0      253.0      163.0       76.0 *     177.   180. AG  1480.  18.1    .0 66.0
       4. Link4               *   164.0      251.0      -70.0      251.0 *     234.   270. AG   738.  21.3    .0 66.0
       5. LinkQ1              *   151.0      298.0      151.0      356.8 *      59.   360. AG   991. 100.0    .0 20.0  .53     3.0
       6. LinkQ2              *   205.0      255.0      297.4      255.0 *      92.    90. AG  1345. 100.0    .0 20.0  .81     4.7
       7. LinkQ3              *   172.0      203.0      172.0      149.4 *      54.   180. AG  1153. 100.0    .0 20.0  .42     2.7
       8. LinkQ4              *   119.0      243.0       84.1      243.3 *      35.   270. AG  1153. 100.0    .0 20.0  .27     1.8

       ADDITIONAL QUEUE LINK PARAMETERS
       --------------------------------
         LINK DESCRIPTION     *   CYCLE    RED      CLEARANCE  APPROACH  SATURATION   IDLE    SIGNAL   ARRIVAL
                              *   LENGTH   TIME     LOST TIME    VOL     FLOW RATE   EM FAC   TYPE      RATE
                              *    (SEC)   (SEC)      (SEC)     (VPH)      (VPH)     (gm/hr)
      ------------------------*-------------------------------------------------------------------------------------
       5. LinkQ1              *     60       28        3.0       768       1600      395.90      1         3
       6. LinkQ2              *     60       38        3.0       738       1600      395.90      1         3
       7. LinkQ3              *     70       38        3.0       516       1600      395.90      1         3
       8. LinkQ4              *     70       38        3.0       337       1600      395.90      1         3

       RECEPTOR LOCATIONS
       ------------------
                              *           COORDINATES (FT)            *
         RECEPTOR             *       X           Y           Z       *
      ------------------------*---------------------------------------*
       1. Rec1                *     333.0       284.0        6.0     *
       2. Rec2                *     268.0       285.0        6.0     *
       3. Rec3                *     199.0       286.0        6.0     *
       4. Rec4                *     201.0       357.0        6.0     *
       5. Rec5                *     201.0       417.0        6.0     *
       6. Rec6                *     333.0       207.0        6.0     *
       7. Rec7                *     268.0       209.0        6.0     *
       8. Rec8                *     199.0       213.0        6.0     *
       9. Rec9                *     203.0       141.0        6.0     *
      10. Rec10               *     203.0        86.0        6.0     *
      11. Rec11               *     125.0        86.0        6.0     *
      12. Rec12               *     125.0       148.0        6.0     *
      13. Rec13               *     126.0       215.0        6.0     *
      14. Rec14               *      59.0       214.0        6.0     *
      15. Rec15               *     -13.0       213.0        6.0     *
      16. Rec16               *     124.0       422.0        6.0     *
      17. Rec17               *     125.0       355.0        6.0     *
      18. Rec18               *     126.0       286.0        6.0     *
      19. Rec19               *      54.0       287.0        6.0     *
      20. Rec20               *     -16.0       288.0        6.0     *
```

```
   JOB: NB/FR CommRail 1998 ExistCond                          RUN: Foundry St/Rt106 and Rte138 TpkSt

     MODEL RESULTS
     -------------

     REMARKS : In search of the angle corresponding to
               the maximum concentration, only the first
               angle, of the angles with same maximum
               concentrations, is indicated as maximum.

 WIND ANGLE RANGE:    0.-360.

 WIND   * CONCENTRATION
 ANGLE  *      (PPM)
 (DEGR) * REC1  REC2  REC3  REC4  REC5  REC6  REC7  REC8  REC9  REC10 REC11 REC12 REC13 REC14 REC15 REC16 REC17 REC18 REC19 REC20
 -------*-------------------------------------------------------------------------------------------------------------------------
   0.   *  5.0   5.0   5.4   5.2   5.0   5.8   8.1   7.4   6.9   7.1   6.6   6.8   7.2   5.5   5.5   5.1   5.3   5.9   5.0   5.0
  10.   *  5.0   5.0   5.2   5.1   5.0   5.7   7.9   7.5   6.6   6.5   7.2   6.9   7.3   5.7   5.4   5.2   5.5   6.8   5.0   5.0
  20.   *  5.0   5.0   5.1   5.0   5.0   5.7   7.6   7.6   6.5   6.2   7.8   7.1   7.1   6.1   5.4   5.2   5.6   7.7   5.1   5.0
  30.   *  5.0   5.0   5.1   5.0   5.0   5.6   7.1   8.1   6.5   5.8   7.9   7.5   6.9   6.9   5.6   5.3   5.7   8.2   5.2   5.0
  40.   *  5.0   5.0   5.0   5.0   5.0   5.5   6.6   8.5   6.1   5.4   7.6   8.4   6.9   7.6   5.9   5.3   5.7   8.0   5.5   5.1
  50.   *  5.0   5.1   5.1   5.0   5.0   5.4   6.2   8.5   5.6   5.2   6.9   8.7   7.2   8.0   6.1   5.4   5.7   7.6   5.8   5.3
  60.   *  5.0   5.1   5.1   5.0   5.0   5.3   5.9   8.2   5.3   5.1   6.1   8.6   7.9   8.2   6.6   5.5   5.7   7.1   6.0   5.4
  70.   *  5.0   5.1   5.1   5.0   5.0   5.2   5.7   7.5   5.1   5.0   5.8   8.0   8.2   8.2   7.2   5.5   6.0   6.8   6.3   5.7
  80.   *  5.1   5.2   5.3   5.0   5.0   5.2   5.6   6.6   5.0   5.0   5.7   7.3   8.1   7.8   7.3   5.6   6.5   6.7   6.4   6.0
  90.   *  5.1   5.4   6.1   5.0   5.0   5.1   5.3   5.8   5.0   5.0   5.6   6.7   7.4   7.1   6.8   5.6   7.0   7.3   6.9   6.7
 100.   *  5.3   5.7   7.2   5.0   5.0   5.0   5.1   5.3   5.0   5.0   5.5   6.2   7.0   6.5   6.2   5.6   7.7   8.0   7.2   7.1
 110.   *  5.3   6.0   8.5   5.1   5.0   5.0   5.1   5.1   5.0   5.0   5.3   5.9   7.0   6.1   5.7   5.6   8.5   8.1   7.5   7.1
 120.   *  5.4   6.6   9.1   5.4   5.0   5.0   5.0   5.1   5.0   5.0   5.2   5.7   7.4   6.0   5.4   5.9   9.3   7.6   7.5   6.7
 130.   *  5.5   7.3   9.2   5.8   5.2   5.0   5.0   5.1   5.0   5.0   5.2   5.8   7.5   5.7   5.1   6.4   9.6   7.2   7.7   6.2
 140.   *  5.6   7.9   8.8   6.3   5.5   5.0   5.0   5.2   5.0   5.0   5.1   5.7   7.4   5.4   5.1   6.9   9.5   7.2   7.4   5.9
 150.   *  5.7   8.4   8.4   6.7   5.9   5.0   5.0   5.1   5.0   5.0   5.1   5.7   6.9   5.2   5.0   7.6   8.9   7.3   6.7   5.6
 160.   *  5.7   8.6   7.9   6.6   6.2   5.0   5.0   5.1   5.0   5.0   5.1   5.6   6.3   5.1   5.0   7.8   8.2   7.5   6.1   5.4
 170.   *  5.8   8.7   7.7   6.8   6.3   5.0   5.0   5.3   5.1   5.0   5.0   5.4   5.9   5.0   5.0   7.7   7.5   7.1   5.6   5.4
 180.   *  5.8   8.8   7.8   7.0   6.8   5.0   5.0   5.8   5.2   5.0   5.0   5.3   5.5   5.0   5.0   6.9   6.6   6.9   5.5   5.5
 190.   *  5.8   9.0   7.9   7.0   7.2   5.0   5.0   6.6   5.3   5.0   5.0   5.1   5.2   5.0   5.0   6.1   6.1   6.8   5.4   5.4
 200.   *  5.8   9.2   7.6   7.0   7.3   5.0   5.1   7.7   5.5   5.0   5.0   5.1   5.1   5.0   5.0   5.5   5.8   7.0   5.4   5.4
 210.   *  6.4   9.6   7.3   7.1   7.2   5.0   5.1   8.3   5.6   5.1   5.0   5.1   5.1   5.0   5.0   5.4   5.6   7.1   5.4   5.4
 220.   *  7.2   9.9   7.0   7.4   6.9   5.1   5.4   8.5   5.6   5.1   5.0   5.1   5.1   5.0   5.0   5.1   5.3   6.9   5.5   5.4
 230.   *  8.3   9.8   7.0   7.6   6.4   5.2   5.8   8.1   5.7   5.1   5.0   5.0   5.1   5.0   5.0   5.1   5.2   6.4   5.5   5.4
 240.   *  9.2   9.4   7.1   7.4   5.9   5.4   6.1   7.7   5.7   5.2   5.0   5.0   5.0   5.0   5.0   5.0   5.2   6.0   5.5   5.3
 250.   *  9.3   8.4   7.1   7.3   5.6   5.8   6.4   7.1   5.7   5.3   5.0   5.0   5.1   5.1   5.0   5.0   5.1   5.7   5.5   5.3
 260.   *  8.7   7.4   6.9   6.9   5.6   6.2   6.5   6.8   5.8   5.5   5.0   5.0   5.2   5.1   5.1   5.0   5.0   5.6   5.4   5.2
 270.   *  7.4   6.7   6.6   6.4   5.6   6.6   6.6   6.9   6.2   5.6   5.0   5.0   5.5   5.3   5.1   5.0   5.0   5.4   5.3   5.1
 280.   *  6.4   6.2   6.6   6.0   5.6   7.5   6.8   7.2   6.8   5.7   5.0   5.0   5.8   5.4   5.2   5.0   5.0   5.2   5.1   5.1
 290.   *  5.6   6.0   6.7   5.8   5.5   8.1   7.1   7.3   7.5   5.7   5.0   5.1   6.4   5.5   5.3   5.0   5.0   5.1   5.1   5.0
 300.   *  5.5   5.9   7.0   5.6   5.5   8.5   7.6   7.2   8.1   5.8   5.0   5.2   7.0   5.5   5.3   5.0   5.0   5.1   5.0   5.0
 310.   *  5.4   5.7   7.2   5.6   5.4   8.3   8.5   7.0   8.7   6.3   5.1   5.2   7.5   5.5   5.4   5.0   5.0   5.0   5.0   5.0
 320.   *  5.2   5.5   7.0   5.7   5.3   7.5   8.6   7.1   9.0   6.8   5.2   5.5   7.8   5.5   5.4   5.0   5.0   5.1   5.0   5.0
 330.   *  5.0   5.2   6.6   5.6   5.3   6.7   8.7   7.3   8.7   7.5   5.4   5.7   7.7   5.4   5.4   5.0   5.1   5.1   5.0   5.0
 340.   *  5.0   5.1   6.2   5.5   5.2   6.0   8.3   7.5   8.2   7.8   5.5   5.9   7.1   5.4   5.4   5.0   5.1   5.1   5.0   5.0
 350.   *  5.0   5.0   5.8   5.4   5.1   5.8   8.2   7.5   7.5   7.7   5.9   6.4   7.0   5.4   5.4   5.0   5.2   5.3   5.0   5.0
 360.   *  5.0   5.0   5.4   5.2   5.0   5.8   8.1   7.4   6.9   7.1   6.6   6.8   7.2   5.5   5.5   5.1   5.3   5.9   5.0   5.0
 -------*-------------------------------------------------------------------------------------------------------------------------
 MAX    *  9.3   9.9   9.2   7.6   7.3   8.5   8.7   8.5   9.0   7.8   7.9   8.7   8.2   8.2   7.3   7.8   9.6   8.2   7.7   7.1
 DEGR.  *  250   220   130   230   200   300   330   40    320   340   30    50    70    60    80    160   130   30    130   100

 THE HIGHEST CONCENTRATION OF    9.90 PPM OCCURRED AT RECEPTOR REC2 .
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CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 95221                      PAGE  1

     JOB: NB/FR CommRail 2010 No Build                         RUN: Foundry St/106 and Rte138 Tpk St

     DATE :  2/ 4/99
     TIME : 15:18:51

        The MODE flag has been set to C for calculating CO averages.

      SITE & METEOROLOGICAL VARIABLES
      -------------------------------
      VS =    .0 CM/S       VD =     .0 CM/S       Z0 = 108. CM
       U =  1.0 M/S         CLAS =    4  (D)     ATIM =  60. MINUTES     MIXH =  1000. M   AMB =  5.0 PPM

      LINK VARIABLES
      --------------
        LINK DESCRIPTION     *         LINK COORDINATES (FT)          *    LENGTH  BRG TYPE  VPH    EF      H   W    V/C QUEUE
                             *   X1        Y1        X2        Y2     *     (FT)   (DEG)         (G/MI)  (FT) (FT)       (VEH)
     ------------------------*------------------------------------------*----------------------------------------------------------
      1. Link1               *   162.0     250.0     161.0     452.0 *     202.   360. AG  1369.   7.9    .0 66.0
      2. Link2               *   161.0     250.0     369.0     247.0 *     208.    91. AG  1454.   9.6    .0 66.0
      3. Link3               *   162.0     253.0     163.0      76.0 *     177.   180. AG  1668.   7.9    .0 66.0
      4. Link4               *   164.0     251.0     -70.0     251.0 *     234.   270. AG   832.   9.6    .0 66.0
      5. LinkQ1              *   151.0     298.0     151.0     388.0 *      90.   360. AG   504. 100.0    .0 20.0  .70    4.6
      6. LinkQ2              *   205.0     255.0     291.4     255.0 *      86.    90. AG   504. 100.0    .0 20.0  .67    4.4
      7. LinkQ3              *   172.0     203.0     172.0     142.3 *      61.   180. AG   504. 100.0    .0 20.0  .47    3.1
      8. LinkQ4              *   119.0     243.0      79.5     243.3 *      39.   270. AG   504. 100.0    .0 20.0  .31    2.0

      ADDITIONAL QUEUE LINK PARAMETERS
      --------------------------------
        LINK DESCRIPTION     *    CYCLE    RED     CLEARANCE  APPROACH  SATURATION   IDLE    SIGNAL   ARRIVAL
                             *    LENGTH   TIME    LOST TIME    VOL     FLOW RATE   EM FAC    TYPE     RATE
                             *    (SEC)    (SEC)     (SEC)     (VPH)      (VPH)     (gm/hr)
     ------------------------*--------------------------------------------------------------------------------
      5. LinkQ1              *      70       38       3.0       866        1600     173.20      1         3
      6. LinkQ2              *      70       38       3.0       832        1600     173.20      1         3
      7. LinkQ3              *      70       38       3.0       584        1600     173.20      1         3
      8. LinkQ4              *      70       38       3.0       380        1600     173.20      1         3

      RECEPTOR LOCATIONS
      ------------------
                             *          COORDINATES (FT)            *
        RECEPTOR             *      X          Y            Z       *
     ------------------------*------------------------------------*
      1. Rec1                *     333.0      284.0         6.0    *
      2. Rec2                *     268.0      285.0         6.0    *
      3. Rec3                *     199.0      286.0         6.0    *
      4. Rec4                *     201.0      357.0         6.0    *
      5. Rec5                *     201.0      417.0         6.0    *
      6. Rec6                *     333.0      207.0         6.0    *
      7. Rec7                *     268.0      209.0         6.0    *
      8. Rec8                *     199.0      213.0         6.0    *
      9. Rec9                *     203.0      141.0         6.0    *
     10. Rec10               *     203.0       86.0         6.0    *
     11. Rec11               *     125.0       86.0         6.0    *
     12. Rec12               *     125.0      148.0         6.0    *
     13. Rec13               *     126.0      215.0         6.0    *
     14. Rec14               *      59.0      214.0         6.0    *
     15. Rec15               *     -13.0      213.0         6.0    *
     16. Rec16               *     124.0      422.0         6.0    *
     17. Rec17               *     125.0      355.0         6.0    *
     18. Rec18               *     126.0      286.0         6.0    *
     19. Rec19               *      54.0      287.0         6.0    *
     20. Rec20               *     -16.0      288.0         6.0    *
```

```
  JOB: NB/FR CommRail 2010 No Build                            RUN: Foundry St/106 and Rte138 Tpk St

   MODEL RESULTS
   -------------

   REMARKS : In search of the angle corresponding to
             the maximum concentration, only the first
             angle, of the angles with same maximum
             concentrations, is indicated as maximum.

WIND ANGLE RANGE:   0.-360.

WIND   * CONCENTRATION
ANGLE  *        (PPM)
(DEGR) * REC1  REC2  REC3  REC4  REC5  REC6  REC7  REC8  REC9  REC10 REC11 REC12 REC13 REC14 REC15 REC16 REC17 REC18 REC19 REC20
------*------------------------------------------------------------------------------------------------------------------------
  0.  *   5.0   5.0   5.2   5.1   5.0   5.4   6.3   6.2   5.8   5.9   5.9   5.9   6.1   5.2   5.2   5.0   5.2   5.6   5.0   5.0
 10.  *   5.0   5.0   5.1   5.0   5.0   5.4   6.2   6.0   5.8   5.7   6.2   6.1   6.3   5.4   5.2   5.1   5.3   6.2   5.0   5.0
 20.  *   5.0   5.0   5.0   5.0   5.0   5.3   6.0   6.1   5.6   5.5   6.3   6.2   6.2   5.7   5.2   5.1   5.5   6.7   5.0   5.0
 30.  *   5.0   5.0   5.0   5.0   5.0   5.3   5.8   6.3   5.6   5.3   6.3   6.3   6.0   6.1   5.3   5.1   5.8   6.8   5.2   5.0
 40.  *   5.0   5.0   5.0   5.0   5.0   5.3   5.6   6.4   5.4   5.2   6.2   6.4   6.0   6.4   5.5   5.2   6.1   6.7   5.4   5.0
 50.  *   5.0   5.0   5.0   5.0   5.0   5.2   5.5   6.4   5.3   5.1   5.8   6.6   6.0   6.4   5.7   5.2   6.4   6.3   5.6   5.2
 60.  *   5.0   5.0   5.0   5.0   5.0   5.2   5.4   6.3   5.1   5.0   5.6   6.6   6.2   6.6   5.8   5.2   6.5   6.1   5.7   5.3
 70.  *   5.0   5.0   5.1   5.0   5.0   5.1   5.4   6.0   5.1   5.0   5.3   6.3   6.4   6.4   6.0   5.3   6.5   5.8   5.6   5.4
 80.  *   5.0   5.1   5.1   5.0   5.0   5.1   5.3   5.6   5.0   5.0   5.3   6.3   6.3   6.3   6.2   5.3   6.5   5.8   5.8   5.7
 90.  *   5.1   5.2   5.5   5.0   5.0   5.0   5.2   5.4   5.0   5.0   5.3   6.0   6.2   6.0   5.8   5.3   6.5   6.1   5.8   5.9
100.  *   5.1   5.3   5.9   5.0   5.0   5.0   5.1   5.1   5.0   5.0   5.2   5.8   5.9   5.8   5.7   5.3   6.5   6.3   6.1   6.2
110.  *   5.2   5.4   6.4   5.0   5.0   5.0   5.0   5.1   5.0   5.0   5.2   5.5   5.9   5.5   5.3   5.3   6.8   6.3   6.1   6.0
120.  *   5.2   5.5   6.6   5.2   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.5   6.1   5.5   5.2   5.6   7.1   6.1   6.3   5.8
130.  *   5.2   5.9   6.7   5.4   5.1   5.0   5.0   5.0   5.0   5.0   5.1   5.4   6.2   5.4   5.1   5.8   7.2   6.1   6.3   5.6
140.  *   5.3   6.0   6.5   5.5   5.2   5.0   5.0   5.0   5.0   5.0   5.1   5.4   6.1   5.2   5.0   6.3   7.1   6.1   6.2   5.5
150.  *   5.3   6.2   6.4   5.7   5.3   5.0   5.0   5.0   5.0   5.0   5.0   5.3   6.0   5.1   5.0   6.6   6.8   6.1   5.9   5.2
160.  *   5.4   6.4   6.2   5.7   5.5   5.0   5.0   5.0   5.0   5.0   5.0   5.3   5.6   5.0   5.0   6.8   6.6   6.1   5.5   5.2
170.  *   5.4   6.5   6.2   5.9   5.7   5.0   5.0   5.1   5.0   5.0   5.0   5.2   5.5   5.0   5.0   6.6   6.4   6.0   5.3   5.2
180.  *   5.4   6.5   6.3   5.8   5.8   5.0   5.0   5.4   5.1   5.0   5.0   5.1   5.2   5.0   5.0   6.0   5.9   5.9   5.2   5.2
190.  *   5.4   6.5   6.3   5.9   5.9   5.0   5.0   5.9   5.2   5.0   5.0   5.1   5.1   5.0   5.0   5.4   5.6   5.8   5.2   5.2
200.  *   5.4   6.8   6.3   6.1   6.3   5.0   5.0   6.3   5.2   5.0   5.0   5.0   5.1   5.0   5.0   5.2   5.3   5.9   5.2   5.2
210.  *   5.5   7.0   6.1   6.1   6.3   5.0   5.1   6.6   5.3   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.2   5.9   5.2   5.2
220.  *   5.8   7.1   6.1   6.1   6.3   5.0   5.2   6.6   5.3   5.1   5.0   5.0   5.0   5.0   5.0   5.1   5.1   6.0   5.3   5.2
230.  *   6.3   7.0   6.1   6.3   6.1   5.1   5.4   6.4   5.3   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.8   5.3   5.2
240.  *   6.6   6.9   6.1   6.3   5.8   5.2   5.6   6.3   5.3   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.5   5.3   5.2
250.  *   6.8   6.4   6.0   6.2   5.5   5.3   5.6   6.0   5.4   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.4   5.3   5.1
260.  *   6.6   6.1   5.8   6.1   5.4   5.4   5.7   5.9   5.7   5.2   5.0   5.0   5.1   5.1   5.0   5.0   5.0   5.3   5.2   5.1
270.  *   6.1   5.8   5.9   6.1   5.3   5.8   5.8   6.0   5.9   5.3   5.0   5.0   5.2   5.1   5.1   5.0   5.0   5.2   5.1   5.1
280.  *   5.5   5.7   5.7   6.1   5.3   6.1   5.9   6.0   6.1   5.3   5.0   5.0   5.5   5.2   5.1   5.0   5.0   5.1   5.1   5.0
290.  *   5.5   5.6   5.8   6.0   5.3   6.6   6.0   6.1   6.4   5.3   5.0   5.1   5.7   5.3   5.1   5.0   5.0   5.0   5.0   5.0
300.  *   5.3   5.6   6.0   5.8   5.2   6.5   6.3   6.0   6.7   5.5   5.0   5.1   6.0   5.3   5.2   5.0   5.0   5.0   5.0   5.0
310.  *   5.2   5.5   6.2   5.6   5.2   6.3   6.4   6.1   6.8   5.7   5.1   5.1   6.2   5.3   5.2   5.0   5.0   5.0   5.0   5.0
320.  *   5.0   5.2   6.3   5.4   5.2   6.0   6.7   6.0   6.8   5.9   5.1   5.2   6.3   5.2   5.2   5.0   5.0   5.0   5.0   5.0
330.  *   5.0   5.1   6.1   5.3   5.1   5.7   6.6   6.3   6.8   6.2   5.2   5.3   6.2   5.2   5.2   5.0   5.0   5.0   5.0   5.0
340.  *   5.0   5.0   5.8   5.3   5.1   5.5   6.5   6.4   6.4   6.6   5.2   5.4   6.0   5.2   5.2   5.0   5.0   5.0   5.0   5.0
350.  *   5.0   5.0   5.5   5.2   5.1   5.4   6.3   6.3   6.3   6.4   5.5   5.7   6.0   5.2   5.2   5.0   5.1   5.2   5.0   5.0
360.  *   5.0   5.0   5.2   5.1   5.0   5.4   6.3   6.2   5.8   5.9   5.9   5.9   6.1   5.2   5.2   5.0   5.2   5.6   5.0   5.0
------*------------------------------------------------------------------------------------------------------------------------
MAX   *   6.8   7.1   6.7   6.3   6.3   6.6   6.7   6.6   6.8   6.6   6.3   6.6   6.4   6.6   6.2   6.8   7.2   6.8   6.3   6.2
DEGR. *  250   220   130   230   200   290   320   210   310   340    20    50    70    60    80   160   130    30   120   100

THE HIGHEST CONCENTRATION OF    7.20 PPM OCCURRED AT RECEPTOR REC17.
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CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 95221                        PAGE  1

      JOB: NB/FR CommRail    2010 Build                          RUN: Foundry St/106 and Rte138 Tpk St

      DATE :  2/ 4/99
      TIME : 15:19:14

         The MODE flag has been set to C for calculating CO averages.

       SITE & METEOROLOGICAL VARIABLES
       -------------------------------
       VS =    .0 CM/S       VD =    .0 CM/S       Z0 = 108. CM
        U =  1.0 M/S         CLAS =   4  (D)     ATIM =  60. MINUTES     MIXH =  1000. M   AMB =  5.0 PPM

       LINK VARIABLES
       --------------
         LINK DESCRIPTION     *        LINK COORDINATES (FT)           *   LENGTH  BRG TYPE  VPH    EF      H   W    V/C QUEUE
                              *  X1         Y1         X2         Y2   *    (FT)  (DEG)            (G/MI)  (FT) (FT)        (VEH)
      ------------------------*--------------------------------------*--------------------------------------------------------------
       1. Link1               *   162.0      250.0      161.0      452.0 *    202.   360. AG  1382.   7.9    .0 66.0
       2. Link2               *   161.0      250.0      369.0      247.0 *    208.    91. AG  1450.   9.6    .0 66.0
       3. Link3               *   162.0      253.0      163.0       76.0 *    177.   180. AG  1681.   7.9    .0 66.0
       4. Link4               *   164.0      251.0      -70.0      251.0 *    234.   270. AG   827.   9.6    .0 66.0
       5. LinkQ1              *   151.0      298.0      151.0      388.4 *     90.   360. AG   504. 100.0    .0 20.0  .71   4.6
       6. LinkQ2              *   205.0      255.0      290.8      255.0 *     86.    90. AG   504. 100.0    .0 20.0  .67   4.4
       7. LinkQ3              *   172.0      203.0      172.0      141.5 *     62.   180. AG   504. 100.0    .0 20.0  .48   3.1
       8. LinkQ4              *   119.0      243.0       79.5      243.3 *     39.   270. AG   504. 100.0    .0 20.0  .31   2.0

       ADDITIONAL QUEUE LINK PARAMETERS
       --------------------------------
         LINK DESCRIPTION     *   CYCLE    RED     CLEARANCE  APPROACH  SATURATION  IDLE    SIGNAL   ARRIVAL
                              *   LENGTH   TIME    LOST TIME   VOL     FLOW RATE   EM FAC   TYPE     RATE
                              *   (SEC)    (SEC)    (SEC)     (VPH)     (VPH)    (gm/hr)
      ------------------------*----------------------------------------------------------------------------------
       5. LinkQ1              *     70      38       3.0       870      1600     173.20      1        3
       6. LinkQ2              *     70      38       3.0       827      1600     173.20      1        3
       7. LinkQ3              *     70      38       3.0       593      1600     173.20      1        3
       8. LinkQ4              *     70      38       3.0       380      1600     173.20      1        3

       RECEPTOR LOCATIONS
       ------------------
                              *       COORDINATES (FT)        *
         RECEPTOR             *      X          Y          Z  *
      ------------------------*-------------------------------*
      1. Rec1                 *     333.0      284.0       6.0  *
      2. Rec2                 *     268.0      285.0       6.0  *
      3. Rec3                 *     199.0      286.0       6.0  *
      4. Rec4                 *     201.0      357.0       6.0  *
      5. Rec5                 *     201.0      417.0       6.0  *
      6. Rec6                 *     333.0      207.0       6.0  *
      7. Rec7                 *     268.0      209.0       6.0  *
      8. Rec8                 *     199.0      213.0       6.0  *
      9. Rec9                 *     203.0      141.0       6.0  *
     10. Rec10                *     203.0       86.0       6.0  *
     11. Rec11                *     125.0       86.0       6.0  *
     12. Rec12                *     125.0      148.0       6.0  *
     13. Rec13                *     126.0      215.0       6.0  *
     14. Rec14                *      59.0      214.0       6.0  *
     15. Rec15                *     -13.0      213.0       6.0  *
     16. Rec16                *     124.0      422.0       6.0  *
     17. Rec17                *     125.0      355.0       6.0  *
     18. Rec18                *     126.0      286.0       6.0  *
     19. Rec19                *      54.0      287.0       6.0  *
     20. Rec20                *     -16.0      288.0       6.0  *
     JOB: NB/FR CommRail    2010 Build                      RUN: Foundry St/106 and Rte138 Tpk St

      MODEL RESULTS
      -------------

      REMARKS : In search of the angle corresponding to
                the maximum concentration, only the first
                angle, of the angles with same maximum
                concentrations, is indicated as maximum.

 WIND ANGLE RANGE:   0.-360.

 WIND   * CONCENTRATION
 ANGLE  *      (PPM)
 (DEGR)* REC1  REC2  REC3  REC4  REC5  REC6  REC7  REC8  REC9  REC10 REC11 REC12 REC13 REC14 REC15 REC16 REC17 REC18 REC19 REC20
 ------*-----------------------------------------------------------------------------------------------------------------------------
   0.  *   5.0   5.0   5.2   5.1   5.0   5.4   6.3   6.2   5.8   5.9   5.9   5.9   6.1   5.2   5.2   5.0   5.2   5.6   5.0   5.0
  10.  *   5.0   5.0   5.1   5.0   5.0   5.4   6.2   6.0   5.8   5.7   6.2   6.1   6.3   5.4   5.2   5.1   5.3   6.3   5.0   5.0
  20.  *   5.0   5.0   5.0   5.0   5.0   5.3   6.0   6.1   5.6   5.5   6.3   6.2   6.2   5.7   5.2   5.1   5.6   6.7   5.0   5.0
  30.  *   5.0   5.0   5.0   5.0   5.0   5.3   5.8   6.3   5.6   5.3   6.3   6.3   6.0   6.1   5.3   5.1   5.8   6.8   5.2   5.0
  40.  *   5.0   5.0   5.0   5.0   5.0   5.3   5.6   6.4   5.4   5.2   6.2   6.4   6.0   6.4   5.5   5.2   6.2   6.7   5.4   5.0
  50.  *   5.0   5.0   5.0   5.0   5.0   5.2   5.5   6.4   5.3   5.1   5.8   6.6   6.0   6.4   5.7   5.2   6.4   6.3   5.6   5.2
  60.  *   5.0   5.0   5.0   5.0   5.0   5.2   5.4   6.3   5.1   5.0   5.6   6.6   6.2   6.6   5.8   5.2   6.5   6.1   5.7   5.3
  70.  *   5.0   5.0   5.1   5.0   5.0   5.1   5.4   6.0   5.1   5.0   5.3   6.3   6.4   6.4   6.0   5.3   6.5   5.8   5.6   5.4
  80.  *   5.0   5.1   5.1   5.0   5.0   5.1   5.3   5.6   5.0   5.0   5.3   6.3   6.3   6.3   6.2   5.3   6.5   5.8   5.8   5.7
  90.  *   5.1   5.2   5.5   5.0   5.0   5.0   5.2   5.4   5.0   5.0   5.3   6.0   6.2   6.0   5.8   5.3   6.5   6.1   5.9   5.9
 100.  *   5.1   5.3   5.9   5.0   5.0   5.0   5.1   5.1   5.0   5.0   5.2   5.8   5.9   5.8   5.7   5.3   6.5   6.3   6.1   6.1
 110.  *   5.2   5.4   6.4   5.0   5.0   5.0   5.0   5.1   5.0   5.0   5.2   5.5   5.9   5.6   5.3   5.3   6.8   6.3   6.1   6.0
 120.  *   5.2   5.5   6.6   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.5   6.1   5.5   5.2   5.5   7.1   6.1   6.3   5.8
 130.  *   5.2   5.8   6.7   5.4   5.1   5.0   5.0   5.0   5.0   5.0   5.1   5.4   6.2   5.4   5.1   5.8   7.2   6.1   6.3   5.6
 140.  *   5.3   6.0   6.5   5.5   5.2   5.0   5.0   5.0   5.0   5.0   5.1   5.4   6.1   5.2   5.0   6.4   7.1   6.1   6.2   5.4
 150.  *   5.3   6.2   6.4   5.6   5.3   5.0   5.0   5.0   5.0   5.0   5.0   5.3   6.0   5.1   5.0   6.6   6.8   6.1   5.9   5.2
 160.  *   5.4   6.4   6.2   5.7   5.5   5.0   5.0   5.0   5.0   5.0   5.0   5.3   5.6   5.0   5.0   6.8   6.6   6.1   5.5   5.2
 170.  *   5.4   6.5   6.2   5.9   5.8   5.0   5.0   5.1   5.0   5.0   5.0   5.2   5.5   5.0   5.0   6.6   6.4   6.0   5.3   5.2
 180.  *   5.4   6.5   6.3   5.8   5.8   5.0   5.0   5.4   5.1   5.0   5.0   5.1   5.2   5.0   5.0   6.0   5.9   5.9   5.2   5.2
 190.  *   5.4   6.5   6.3   5.9   5.9   5.0   5.0   5.9   5.2   5.0   5.0   5.1   5.1   5.0   5.0   5.4   5.6   5.8   5.2   5.2
 200.  *   5.4   6.8   6.3   6.1   6.3   5.0   5.0   6.3   5.2   5.0   5.0   5.0   5.1   5.0   5.0   5.2   5.3   5.9   5.2   5.2
 210.  *   5.5   7.0   6.1   6.1   6.3   5.0   5.1   6.6   5.3   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.2   5.9   5.2   5.2
 220.  *   5.8   7.0   6.1   6.1   6.3   5.0   5.2   6.6   5.3   5.1   5.0   5.0   5.0   5.0   5.0   5.1   5.1   6.0   5.2   5.2
 230.  *   6.3   7.0   6.0   6.3   6.1   5.1   5.4   6.4   5.3   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.8   5.3   5.2
 240.  *   6.6   6.9   6.1   6.3   5.7   5.2   5.6   6.3   5.3   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.5   5.3   5.2
 250.  *   6.8   6.4   6.0   6.2   5.5   5.3   5.6   6.0   5.4   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.4   5.3   5.1
 260.  *   6.6   6.1   5.8   6.1   5.4   5.4   5.7   5.9   5.7   5.2   5.0   5.0   5.1   5.1   5.0   5.0   5.0   5.3   5.2   5.1
 270.  *   6.1   5.9   5.9   6.1   5.3   5.8   5.8   6.0   5.9   5.3   5.0   5.0   5.2   5.1   5.1   5.0   5.0   5.2   5.1   5.1
 280.  *   5.5   5.7   5.7   6.1   5.3   6.1   5.9   6.0   6.2   5.3   5.0   5.0   5.5   5.2   5.1   5.0   5.0   5.1   5.1   5.0
 290.  *   5.5   5.6   5.8   6.0   5.3   6.6   6.0   6.1   6.4   5.3   5.0   5.0   5.7   5.3   5.1   5.0   5.0   5.0   5.0   5.0
 300.  *   5.3   5.6   6.0   5.8   5.2   6.5   6.3   6.0   6.7   5.5   5.0   5.1   6.0   5.3   5.2   5.0   5.0   5.0   5.0   5.0
 310.  *   5.2   5.5   6.2   5.6   5.2   6.3   6.5   6.1   6.8   5.7   5.1   5.1   6.2   5.3   5.2   5.0   5.0   5.0   5.0   5.0
 320.  *   5.0   5.2   6.3   5.4   5.2   6.0   6.7   6.1   6.8   5.9   5.1   5.2   6.3   5.2   5.2   5.0   5.0   5.0   5.0   5.0
 330.  *   5.0   5.1   6.1   5.3   5.1   5.7   6.6   6.3   6.8   6.2   5.2   5.3   6.2   5.2   5.2   5.0   5.0   5.0   5.0   5.0
 340.  *   5.0   5.0   5.8   5.3   5.1   5.5   6.5   6.4   6.4   6.6   5.2   5.4   6.0   5.2   5.2   5.0   5.0   5.0   5.0   5.0
 350.  *   5.0   5.0   5.5   5.2   5.1   5.4   6.3   6.3   6.3   6.4   5.5   5.7   6.0   5.2   5.2   5.0   5.1   5.2   5.0   5.0
 360.  *   5.0   5.0   5.2   5.1   5.0   5.4   6.3   6.2   5.8   5.9   5.9   5.9   6.1   5.2   5.2   5.0   5.2   5.6   5.0   5.0
 ------*-----------------------------------------------------------------------------------------------------------------------------
 MAX   *   6.8   7.0   6.7   6.3   6.3   6.6   6.7   6.6   6.8   6.6   6.3   6.6   6.4   6.6   6.2   6.8   7.2   6.8   6.3   6.1
 DEGR. *   250   210   130   230   200   290   320   210   310   340    20    50    70    60    80   160   130    30   120   100

 THE HIGHEST CONCENTRATION OF     7.20 PPM OCCURRED AT RECEPTOR REC17.
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CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 95221                       PAGE  1

      JOB: NB/FR CommRail 1998 ExistCond                         RUN: Torrey/Main St and Rte138 WashSt

      DATE :  2/ 4/99
      TIME : 15:20: 3

         The MODE flag has been set to C for calculating CO averages.

       SITE & METEOROLOGICAL VARIABLES
       -------------------------------
       VS =    .0 CM/S         VD =    .0 CM/S       Z0 = 108. CM
        U =  1.0 M/S           CLAS =   4  (D)      ATIM =  60. MINUTES     MIXH =  1000. M   AMB =  5.0 PPM

       LINK VARIABLES
       --------------
         LINK DESCRIPTION      *         LINK COORDINATES (FT)           *    LENGTH  BRG TYPE  VPH    EF      H   W    V/C QUEUE
                               *  X1        Y1        X2        Y2       *     (FT)  (DEG)            (G/MI)  (FT) (FT)        (VEH)
      -------------------------*-----------------------------------------*-----------------------------------------------------------
       1. Link1                *   162.0     250.0     161.0     452.0 *     202.   360. AG  1373.  21.3    .0 66.0
       2. Link2                *   161.0     250.0     369.0     247.0 *     208.    91. AG   695.  18.1    .0 42.0
       3. Link3                *   162.0     253.0     163.0      76.0 *     177.   180. AG  1369.  21.3    .0 66.0
       4. Link4                *   164.0     251.0     -70.0     251.0 *     234.   270. AG   785.  18.1    .0 42.0
       5. LinkQ1               *   151.0     298.0     151.0     358.6 *      61.   360. AG   991. 100.0    .0 20.0  .55    3.1
       6. LinkQ2               *   205.0     255.0     304.7     255.0 *     100.    90. AG   673. 100.0    .0 10.0  .84    5.1
       7. LinkQ3               *   172.0     203.0     172.0     140.0 *      63.   180. AG  1153. 100.0    .0 20.0  .49    3.2
       8. LinkQ4               *   119.0     243.0      49.8     243.5 *      69.   270. AG   576. 100.0    .0 10.0  .54    3.5

       ADDITIONAL QUEUE LINK PARAMETERS
       --------------------------------
         LINK DESCRIPTION      *   CYCLE    RED     CLEARANCE  APPROACH  SATURATION   IDLE    SIGNAL   ARRIVAL
                               *   LENGTH   TIME    LOST TIME    VOL     FLOW RATE   EM FAC   TYPE      RATE
                               *    (SEC)   (SEC)     (SEC)     (VPH)      (VPH)    (gm/hr)
      -------------------------*--------------------------------------------------------------------------------
       5. LinkQ1               *     60       28       3.0       793       1600     395.90      1         3
       6. LinkQ2               *     60       38       3.0       380       1600     395.90      1         3
       7. LinkQ3               *     70       38       3.0       606       1600     395.90      1         3
       8. LinkQ4               *     70       38       3.0       333       1600     395.90      1         3

       RECEPTOR LOCATIONS
       ------------------
                               *         COORDINATES (FT)          *
         RECEPTOR              *     X           Y           Z     *
     --------------------------*-----------------------------------*
      1. Rec1                  *     333.0       284.0        6.0   *
      2. Rec2                  *     268.0       285.0        6.0   *
      3. Rec3                  *     199.0       286.0        6.0   *
      4. Rec4                  *     201.0       357.0        6.0   *
      5. Rec5                  *     201.0       417.0        6.0   *
      6. Rec6                  *     333.0       207.0        6.0   *
      7. Rec7                  *     268.0       209.0        6.0   *
      8. Rec8                  *     199.0       213.0        6.0   *
      9. Rec9                  *     203.0       141.0        6.0   *
     10. Rec10                 *     203.0        86.0        6.0   *
     11. Rec11                 *     125.0        86.0        6.0   *
     12. Rec12                 *     125.0       148.0        6.0   *
     13. Rec13                 *     126.0       215.0        6.0   *
     14. Rec14                 *      59.0       214.0        6.0   *
     15. Rec15                 *     -13.0       213.0        6.0   *
     16. Rec16                 *     124.0       422.0        6.0   *
     17. Rec17                 *     125.0       355.0        6.0   *
     18. Rec18                 *     126.0       286.0        6.0   *
     19. Rec19                 *      54.0       287.0        6.0   *
     20. Rec20                 *     -16.0       288.0        6.0   *
```

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JOB: NB/FR CommRail 1998 ExistCond                    RUN: Torrey/Main St and Rte138 WashSt

 MODEL RESULTS
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 REMARKS : In search of the angle corresponding to
           the maximum concentration, only the first
           angle, of the angles with same maximum
           concentrations, is indicated as maximum.

WIND ANGLE RANGE:   0.-360.

WIND   * CONCENTRATION
ANGLE  *      (PPM)
(DEGR) * REC1  REC2  REC3  REC4  REC5  REC6  REC7  REC8  REC9  REC10 REC11 REC12 REC13 REC14 REC15 REC16 REC17 REC18 REC19 REC20
-------*------------------------------------------------------------------------------------------------------------------------
  0.   *  5.0   5.0   5.6   5.3   5.1   5.3   6.2   6.5   6.5   6.9   6.7   6.6   7.0   6.3   5.4   5.1   5.4   6.1   5.0   5.0
 10.   *  5.0   5.0   5.2   5.1   5.0   5.3   6.2   6.1   5.9   6.0   7.3   6.9   7.4   6.6   5.4   5.2   5.7   7.1   5.0   5.0
 20.   *  5.0   5.0   5.1   5.1   5.0   5.3   6.1   6.1   5.8   5.5   7.6   7.0   7.2   6.9   5.4   5.3   5.8   8.1   5.1   5.0
 30.   *  5.0   5.0   5.1   5.0   5.0   5.2   6.0   6.2   5.7   5.3   7.7   7.2   7.0   7.3   5.6   5.3   5.9   8.4   5.2   5.0
 40.   *  5.0   5.0   5.1   5.0   5.0   5.2   5.8   6.4   5.5   5.2   7.4   7.7   6.6   7.6   5.9   5.4   5.9   8.4   5.6   5.1
 50.   *  5.0   5.0   5.0   5.0   5.0   5.1   5.5   6.4   5.3   5.1   6.8   8.1   6.6   7.3   6.2   5.5   6.0   7.8   5.9   5.3
 60.   *  5.0   5.0   5.0   5.0   5.0   5.1   5.4   6.3   5.1   5.0   6.2   8.2   6.8   7.0   6.5   5.6   6.0   7.3   6.1   5.5
 70.   *  5.0   5.0   5.0   5.0   5.0   5.0   5.2   6.0   5.0   5.0   5.7   7.9   7.0   6.8   6.6   5.7   6.4   6.8   6.2   5.7
 80.   *  5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.6   5.0   5.0   5.7   7.6   6.7   6.5   6.6   5.8   6.9   6.5   6.2   5.8
 90.   *  5.0   5.1   5.3   5.0   5.0   5.0   5.1   5.2   5.0   5.0   5.7   7.3   6.7   6.4   6.3   5.9   7.5   6.6   6.3   6.2
100.   *  5.0   5.1   5.9   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.5   6.8   6.8   6.3   5.9   5.8   7.9   6.7   6.2   6.4
110.   *  5.1   5.5   6.4   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.3   6.3   7.0   6.3   5.7   5.8   8.5   7.0   6.5   6.7
120.   *  5.1   5.7   6.7   5.2   5.0   5.0   5.0   5.0   5.0   5.0   5.2   6.0   7.5   6.2   5.4   5.9   8.8   6.9   6.7   6.6
130.   *  5.2   6.1   6.7   5.3   5.0   5.0   5.0   5.1   5.0   5.0   5.2   5.8   7.8   5.8   5.3   6.3   9.0   6.7   6.9   6.3
140.   *  5.2   6.4   6.6   5.6   5.2   5.0   5.0   5.1   5.0   5.0   5.1   5.8   7.7   5.4   5.1   6.8   9.1   7.0   7.1   5.8
150.   *  5.3   6.4   6.3   5.7   5.4   5.0   5.0   5.1   5.0   5.0   5.1   5.7   7.2   5.2   5.0   7.3   8.7   7.3   6.8   5.5
160.   *  5.3   6.4   6.2   5.8   5.5   5.0   5.0   5.1   5.0   5.0   5.1   5.6   6.6   5.1   5.0   7.8   8.4   7.5   6.5   5.4
170.   *  5.3   6.4   6.2   6.0   5.8   5.0   5.0   5.3   5.1   5.0   5.0   5.5   6.0   5.0   5.0   7.8   7.6   7.2   6.2   5.4
180.   *  5.3   6.5   6.8   6.5   6.4   5.0   5.0   5.9   5.2   5.0   5.0   5.3   5.5   5.0   5.0   6.8   6.6   6.6   5.9   5.4
190.   *  5.3   6.6   7.4   6.8   7.1   5.0   5.0   6.9   5.4   5.0   5.0   5.1   5.2   5.0   5.0   6.0   6.0   6.2   5.7   5.4
200.   *  5.4   6.8   7.3   7.1   7.4   5.0   5.1   8.0   5.5   5.0   5.0   5.1   5.1   5.0   5.0   5.4   5.7   6.1   5.5   5.4
210.   *  5.7   7.3   7.0   6.9   7.5   5.0   5.2   8.6   5.6   5.1   5.0   5.1   5.1   5.0   5.0   5.3   5.6   6.2   5.4   5.4
220.   *  6.3   7.7   6.8   7.4   7.0   5.1   5.5   8.8   5.7   5.1   5.0   5.1   5.1   5.0   5.0   5.2   5.5   6.2   5.4   5.4
230.   *  7.0   7.5   6.6   7.7   6.5   5.2   5.9   8.3   5.8   5.2   5.0   5.0   5.1   5.0   5.0   5.1   5.4   6.2   5.4   5.3
240.   *  7.3   7.1   6.7   7.6   6.1   5.5   6.3   7.7   5.9   5.2   5.0   5.0   5.0   5.0   5.0   5.0   5.1   6.0   5.4   5.2
250.   *  7.3   6.9   6.8   7.4   5.8   5.8   6.5   7.2   6.0   5.3   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.8   5.4   5.1
260.   *  7.0   6.3   6.6   7.1   5.8   5.8   6.4   6.8   6.6   5.5   5.0   5.0   5.1   5.0   5.0   5.0   5.0   5.5   5.2   5.1
270.   *  6.3   6.2   6.5   6.7   5.8   6.1   6.3   6.6   7.2   5.7   5.0   5.0   5.3   5.1   5.0   5.0   5.0   5.2   5.1   5.0
280.   *  5.9   6.0   6.6   6.3   5.8   6.4   6.2   6.7   7.7   5.7   5.0   5.0   5.7   5.2   5.1   5.0   5.0   5.1   5.0   5.0
290.   *  5.6   6.2   6.9   6.0   5.7   6.6   6.4   6.8   8.3   5.7   5.0   5.1   6.1   5.4   5.1   5.0   5.0   5.0   5.0   5.0
300.   *  5.5   6.0   7.2   5.8   5.6   6.8   6.6   6.6   8.7   6.0   5.0   5.1   6.5   5.4   5.2   5.0   5.0   5.0   5.0   5.0
310.   *  5.3   5.7   7.4   5.9   5.5   6.9   6.8   6.7   8.9   6.4   5.1   5.3   6.5   5.4   5.3   5.0   5.1   5.1   5.0   5.0
320.   *  5.1   5.5   7.3   5.9   5.4   6.3   6.9   6.8   9.0   6.9   5.3   5.5   6.5   5.5   5.4   5.0   5.1   5.1   5.0   5.0
330.   *  5.0   5.2   6.9   5.8   5.3   5.8   6.9   7.3   8.5   7.7   5.3   5.7   6.3   5.6   5.4   5.0   5.1   5.1   5.0   5.0
340.   *  5.0   5.1   6.4   5.7   5.3   5.5   6.5   7.2   8.1   8.1   5.4   5.7   6.2   5.8   5.3   5.0   5.1   5.1   5.0   5.0
350.   *  5.0   5.0   6.0   5.5   5.2   5.4   6.3   7.0   7.2   7.8   5.7   6.1   6.4   6.1   5.4   5.0   5.2   5.4   5.0   5.0
360.   *  5.0   5.0   5.6   5.3   5.1   5.3   6.2   6.5   6.5   6.9   6.7   6.6   7.0   6.3   5.4   5.1   5.4   6.1   5.0   5.0
-------*------------------------------------------------------------------------------------------------------------------------
MAX    *  7.3   7.7   7.4   7.7   7.5   6.9   6.9   8.8   9.0   8.1   7.7   8.2   7.8   7.6   6.6   7.8   9.1   8.4   7.1   6.7
DEGR.  *  240   220   190   230   210   310   320   220   320   340   30    60    130   40    80    160   140   30    140   110

THE HIGHEST CONCENTRATION OF    9.10 PPM OCCURRED AT RECEPTOR REC17.
```

```
CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 95221                 PAGE  1

      JOB: NB/FR CommRail 2010 No Build                         RUN: Torrey/Main St and Rte138 WashSt

      DATE :  2/ 4/99
      TIME : 15:20:23

         The MODE flag has been set to C for calculating CO averages.

       SITE & METEOROLOGICAL VARIABLES
       -------------------------------
       VS =    .0 CM/S        VD =    .0 CM/S       Z0 = 108. CM
        U =  1.0 M/S          CLAS =   4  (D)      ATIM =  60. MINUTES     MIXH =  1000. M   AMB =  5.0 PPM

       LINK VARIABLES
       --------------
         LINK DESCRIPTION      *          LINK COORDINATES (FT)            *    LENGTH  BRG TYPE   VPH    EF      H   W     V/C QUEUE
                               *   X1        Y1        X2         Y2       *     (FT)  (DEG)            (G/MI)  (FT) (FT)        (VEH)
      -------------------------*-------------------------------------------*--------------------------------------------------------------
       1. Link1                *   162.0     250.0     161.0      452.0 *     202.   360. AG   1527.   9.6    .0 66.0
       2. Link2                *   161.0     250.0     369.0      247.0 *     208.    91. AG    781.   7.9    .0 42.0
       3. Link3                *   162.0     253.0     163.0       76.0 *     177.   180. AG   1523.   9.6    .0 66.0
       4. Link4                *   164.0     251.0     -70.0      251.0 *     234.   270. AG    879.   7.9    .0 42.0
       5. LinkQ1               *   151.0     298.0     151.0      364.9 *      67.   360. AG    434. 100.0    .0 20.0  .61    3.4
       6. LinkQ2               *   205.0     255.0     354.2      255.0 *     149.    90. AG    294. 100.0    .0 10.0  .94    7.6
       7. LinkQ3               *   172.0     203.0     172.0      132.1 *      71.   180. AG    504. 100.0    .0 20.0  .55    3.6
       8. LinkQ4               *   119.0     243.0      41.9      243.6 *      77.   270. AG    252. 100.0    .0 10.0  .60    3.9

       ADDITIONAL QUEUE LINK PARAMETERS
       --------------------------------
         LINK DESCRIPTION      *    CYCLE    RED     CLEARANCE  APPROACH  SATURATION   IDLE   SIGNAL   ARRIVAL
                               *    LENGTH   TIME    LOST TIME    VOL     FLOW RATE   EM FAC   TYPE     RATE
                               *    (SEC)   (SEC)     (SEC)      (VPH)      (VPH)    (gm/hr)
      -------------------------*----------------------------------------------------------------------------
       5. LinkQ1               *     60       28        3.0        874       1600     173.20     1        3
       6. LinkQ2               *     60       38        3.0        427       1600     173.20     1        3
       7. LinkQ3               *     70       38        3.0        682       1600     173.20     1        3
       8. LinkQ4               *     70       38        3.0        371       1600     173.20     1        3

       RECEPTOR LOCATIONS
       ------------------
                               *          COORDINATES (FT)         *
         RECEPTOR              *      X          Y           Z     *
      -------------------------*-----------------------------------*
      1. Rec1                  *     333.0      284.0       6.0    *
      2. Rec2                  *     268.0      285.0       6.0    *
      3. Rec3                  *     199.0      286.0       6.0    *
      4. Rec4                  *     201.0      357.0       6.0    *
      5. Rec5                  *     201.0      417.0       6.0    *
      6. Rec6                  *     333.0      207.0       6.0    *
      7. Rec7                  *     268.0      209.0       6.0    *
      8. Rec8                  *     199.0      213.0       6.0    *
      9. Rec9                  *     203.0      141.0       6.0    *
     10. Rec10                 *     203.0       86.0       6.0    *
     11. Rec11                 *     125.0       86.0       6.0    *
     12. Rec12                 *     125.0      148.0       6.0    *
     13. Rec13                 *     126.0      215.0       6.0    *
     14. Rec14                 *      59.0      214.0       6.0    *
     15. Rec15                 *     -13.0      213.0       6.0    *
     16. Rec16                 *     124.0      422.0       6.0    *
     17. Rec17                 *     125.0      355.0       6.0    *
     18. Rec18                 *     126.0      286.0       6.0    *
     19. Rec19                 *      54.0      287.0       6.0    *
     20. Rec20                 *     -16.0      288.0       6.0    *
```

```
JOB: NB/FR CommRail 2010 No Build                     RUN: Torrey/Main St and Rte138 WashSt

   MODEL RESULTS
   -------------

   REMARKS : In search of the angle corresponding to
             the maximum concentration, only the first
             angle, of the angles with same maximum
             concentrations, is indicated as maximum.

WIND ANGLE RANGE:    0.-360.

WIND   * CONCENTRATION
ANGLE  *      (PPM)
(DEGR) * REC1  REC2  REC3  REC4  REC5  REC6  REC7  REC8  REC9  REC10 REC11 REC12 REC13 REC14 REC15 REC16 REC17 REC18 REC19 REC20
-------*------------------------------------------------------------------------------------------------------------------------
  0.   *   5.0   5.0   5.3   5.2   5.0   5.6   5.6   5.8   5.8   5.9   5.8   5.8   6.0   5.6   5.2   5.1   5.2   5.5   5.0   5.0
 10.   *   5.0   5.0   5.1   5.1   5.0   5.4   5.6   5.5   5.5   5.5   5.9   5.8   6.2   5.7   5.2   5.1   5.3   6.1   5.0   5.0
 20.   *   5.0   5.0   5.1   5.0   5.0   5.3   5.6   5.5   5.3   5.3   6.3   5.9   6.1   5.8   5.2   5.1   5.4   6.4   5.1   5.0
 30.   *   5.0   5.0   5.0   5.0   5.0   5.2   5.6   5.6   5.3   5.3   6.3   6.2   6.0   6.1   5.3   5.2   5.5   6.6   5.1   5.0
 40.   *   5.0   5.0   5.0   5.0   5.0   5.2   5.6   5.7   5.3   5.1   6.4   6.4   5.9   6.2   5.4   5.2   5.6   6.6   5.3   5.1
 50.   *   5.0   5.0   5.0   5.0   5.0   5.1   5.6   5.7   5.3   5.1   6.0   6.4   5.8   6.0   5.6   5.3   5.6   6.3   5.4   5.1
 60.   *   5.0   5.0   5.0   5.0   5.0   5.0   5.5   5.7   5.1   5.0   5.7   6.5   5.9   6.0   5.7   5.3   5.7   6.1   5.6   5.2
 70.   *   5.0   5.0   5.0   5.0   5.0   5.0   5.2   5.6   5.0   5.0   5.4   6.5   5.9   5.9   5.8   5.4   6.0   5.8   5.6   5.4
 80.   *   5.0   5.0   5.1   5.0   5.0   5.0   5.2   5.3   5.0   5.0   5.4   6.3   5.9   5.9   5.8   5.4   6.2   5.7   5.6   5.5
 90.   *   5.0   5.1   5.3   5.0   5.0   5.0   5.0   5.2   5.0   5.0   5.3   6.2   5.9   5.6   5.6   5.4   6.3   5.8   5.7   5.4
100.   *   5.0   5.3   5.5   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.3   6.0   5.7   5.5   5.4   5.4   6.4   5.8   5.8   5.6
110.   *   5.0   5.5   5.8   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.2   5.8   5.9   5.6   5.3   5.4   6.6   5.9   5.8   5.7
120.   *   5.1   5.7   5.8   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.6   6.1   5.5   5.2   5.5   6.8   5.9   5.9   5.7
130.   *   5.2   5.8   5.8   5.3   5.1   5.0   5.0   5.0   5.0   5.0   5.1   5.5   6.3   5.4   5.1   5.7   6.9   5.9   6.0   5.7
140.   *   5.3   5.7   5.7   5.3   5.1   5.0   5.0   5.0   5.0   5.0   5.1   5.4   6.3   5.3   5.0   6.0   6.9   6.0   6.0   5.5
150.   *   5.5   5.7   5.7   5.3   5.3   5.0   5.0   5.0   5.0   5.0   5.0   5.4   6.1   5.1   5.0   6.1   6.8   6.2   6.0   5.2
160.   *   5.5   5.7   5.5   5.3   5.3   5.0   5.0   5.1   5.0   5.0   5.0   5.3   5.8   5.0   5.0   6.3   6.4   6.2   5.8   5.2
170.   *   5.7   5.7   5.6   5.6   5.5   5.0   5.0   5.2   5.0   5.0   5.0   5.2   5.5   5.0   5.0   6.4   6.1   6.1   5.5   5.2
180.   *   5.7   5.7   6.0   5.8   5.6   5.0   5.0   5.5   5.1   5.0   5.0   5.2   5.3   5.0   5.0   6.0   5.8   5.8   5.5   5.2
190.   *   5.7   5.7   6.2   5.8   6.0   5.0   5.0   6.0   5.2   5.0   5.0   5.1   5.1   5.0   5.0   5.5   5.4   5.5   5.4   5.2
200.   *   5.7   5.9   6.1   5.9   6.1   5.0   5.0   6.5   5.2   5.0   5.0   5.0   5.1   5.0   5.0   5.3   5.3   5.5   5.3   5.2
210.   *   5.7   6.2   5.9   6.0   6.2   5.0   5.1   6.7   5.3   5.0   5.0   5.0   5.0   5.0   5.0   5.2   5.2   5.5   5.3   5.2
220.   *   6.0   6.2   5.8   6.2   6.1   5.0   5.2   6.7   5.4   5.1   5.0   5.0   5.0   5.0   5.0   5.1   5.2   5.6   5.2   5.2
230.   *   6.1   6.1   5.8   6.2   5.8   5.1   5.5   6.5   5.5   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.5   5.2   5.1
240.   *   6.1   5.9   5.9   6.3   5.5   5.2   5.6   6.3   5.6   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.5   5.2   5.1
250.   *   5.9   5.7   5.9   6.2   5.4   5.4   5.6   6.0   5.9   5.2   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.4   5.2   5.1
260.   *   5.9   5.7   5.7   6.0   5.4   5.5   5.6   5.7   6.1   5.2   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.3   5.1   5.0
270.   *   5.7   5.5   5.7   5.9   5.4   5.5   5.6   5.7   6.3   5.3   5.0   5.0   5.2   5.0   5.0   5.0   5.0   5.1   5.0   5.0
280.   *   5.4   5.4   5.7   5.7   5.4   5.7   5.6   5.8   6.5   5.4   5.0   5.0   5.4   5.1   5.0   5.0   5.0   5.0   5.0   5.0
290.   *   5.4   5.5   5.9   5.6   5.4   5.9   5.6   5.8   6.6   5.4   5.0   5.0   5.5   5.2   5.1   5.0   5.0   5.0   5.0   5.0
300.   *   5.2   5.5   6.0   5.5   5.3   5.8   5.9   5.9   6.7   5.5   5.0   5.1   5.7   5.2   5.1   5.0   5.0   5.0   5.0   5.0
310.   *   5.1   5.4   6.2   5.4   5.3   5.9   5.9   5.8   6.7   5.8   5.0   5.2   5.7   5.3   5.2   5.0   5.0   5.0   5.0   5.0
320.   *   5.1   5.3   6.1   5.4   5.2   5.8   6.0   6.0   6.9   6.1   5.1   5.2   5.7   5.3   5.2   5.0   5.0   5.0   5.0   5.0
330.   *   5.0   5.1   5.9   5.4   5.2   5.7   5.9   5.9   6.7   6.5   5.2   5.3   5.6   5.4   5.2   5.0   5.0   5.0   5.0   5.0
340.   *   5.0   5.1   5.7   5.4   5.1   5.6   5.7   6.0   6.3   6.4   5.2   5.3   5.5   5.5   5.2   5.0   5.0   5.1   5.0   5.0
350.   *   5.0   5.0   5.5   5.3   5.1   5.5   5.5   6.0   6.0   6.3   5.5   5.5   5.6   5.6   5.2   5.0   5.1   5.3   5.0   5.0
360.   *   5.0   5.0   5.3   5.2   5.0   5.6   5.6   5.8   5.8   5.9   5.8   5.8   6.0   5.6   5.2   5.1   5.2   5.5   5.0   5.0
-------*------------------------------------------------------------------------------------------------------------------------
MAX    *   6.1   6.2   6.2   6.3   6.2   5.9   6.0   6.7   6.9   6.5   6.4   6.5   6.3   6.2   5.8   6.4   6.9   6.6   6.0   5.7
DEGR.  *   230   210   190   240   210   290   320   210   320   330    40    60   130    40    70   170   130    30   130   110

THE HIGHEST CONCENTRATION OF     6.90 PPM OCCURRED AT RECEPTOR REC17.
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CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 95221                         PAGE  1

      JOB: NB/FR CommRail 2010 Build                           RUN: Torrey/Main St and Rte138 WashSt

      DATE :  2/ 4/99
      TIME : 15:20:42

         The MODE flag has been set to C for calculating CO averages.

       SITE & METEOROLOGICAL VARIABLES
       -------------------------------
       VS =     .0 CM/S        VD =     .0 CM/S       Z0 = 108. CM
        U =  1.0 M/S           CLAS =   4  (D)      ATIM =  60. MINUTES     MIXH =  1000. M   AMB =  5.0 PPM

       LINK VARIABLES
       --------------
         LINK DESCRIPTION      *         LINK COORDINATES (FT)            *   LENGTH  BRG TYPE   VPH    EF      H   W    V/C QUEUE
                               *   X1         Y1         X2         Y2    *    (FT)  (DEG)            (G/MI)  (FT) (FT)        (VEH)
      -------------------------*------------------------------------------*-----------------------------------------------------------
       1. Link1                *   162.0      250.0      161.0      452.0 *    202.   360. AG   2056.    9.6    .0 66.0
       2. Link2                *   161.0      250.0      369.0      247.0 *    208.    91. AG    853.    7.9    .0 42.0
       3. Link3                *   162.0      253.0      163.0       76.0 *    177.   180. AG   1804.    9.6    .0 66.0
       4. Link4                *   164.0      251.0      -70.0      251.0 *    234.   270. AG   1054.    7.9    .0 42.0
       5. LinkQ1               *   151.0      298.0      151.0      434.4 *    136.   360. AG    434. 100.0    .0 20.0  .89    6.9
       6. LinkQ2               *   205.0      255.0      383.9      255.0 *    179.    90. AG    294. 100.0    .0 10.0  .98    9.1
       7. LinkQ3               *   172.0      203.0      172.0      125.5 *     78.   180. AG    504. 100.0    .0 20.0  .60    3.9
       8. LinkQ4               *   119.0      243.0       34.0      243.6 *     85.   270. AG    252. 100.0    .0 10.0  .66    4.3

       ADDITIONAL QUEUE LINK PARAMETERS
       --------------------------------
         LINK DESCRIPTION      *   CYCLE    RED    CLEARANCE  APPROACH  SATURATION   IDLE   SIGNAL   ARRIVAL
                               *   LENGTH   TIME   LOST TIME    VOL     FLOW RATE   EM FAC   TYPE     RATE
                               *   (SEC)   (SEC)     (SEC)     (VPH)      (VPH)    (gm/hr)
      -------------------------*------------------------------------------------------------------------------
       5. LinkQ1               *    60       28       3.0       1284       1600     173.20     1        3
       6. LinkQ2               *    60       38       3.0        444       1600     173.20     1        3
       7. LinkQ3               *    70       38       3.0        746       1600     173.20     1        3
       8. LinkQ4               *    70       38       3.0        409       1600     173.20     1        3

       RECEPTOR LOCATIONS
       ------------------
                               *           COORDINATES (FT)           *
         RECEPTOR              *      X           Y            Z      *
      -------------------------*--------------------------------------*
      1. Rec1                  *     333.0       284.0         6.0    *
      2. Rec2                  *     268.0       285.0         6.0    *
      3. Rec3                  *     199.0       286.0         6.0    *
      4. Rec4                  *     201.0       357.0         6.0    *
      5. Rec5                  *     201.0       417.0         6.0    *
      6. Rec6                  *     333.0       207.0         6.0    *
      7. Rec7                  *     268.0       209.0         6.0    *
      8. Rec8                  *     199.0       213.0         6.0    *
      9. Rec9                  *     203.0       141.0         6.0    *
     10. Rec10                 *     203.0        86.0         6.0    *
     11. Rec11                 *     125.0        86.0         6.0    *
     12. Rec12                 *     125.0       148.0         6.0    *
     13. Rec13                 *     126.0       215.0         6.0    *
     14. Rec14                 *      59.0       214.0         6.0    *
     15. Rec15                 *     -13.0       213.0         6.0    *
     16. Rec16                 *     124.0       422.0         6.0    *
     17. Rec17                 *     125.0       355.0         6.0    *
     18. Rec18                 *     126.0       286.0         6.0    *
     19. Rec19                 *      54.0       287.0         6.0    *
     20. Rec20                 *     -16.0       288.0         6.0    *
```

```
    JOB: NB/FR CommRail 2010 Build                          RUN: Torrey/Main St and Rte138 WashSt

      MODEL RESULTS
      -------------

      REMARKS : In search of the angle corresponding to
                the maximum concentration, only the first
                angle, of the angles with same maximum
                concentrations, is indicated as maximum.

 WIND ANGLE RANGE:   0.-360.

 WIND   * CONCENTRATION
 ANGLE  *      (PPM)
 (DEGR) * REC1  REC2  REC3  REC4  REC5  REC6  REC7  REC8  REC9  REC10 REC11 REC12 REC13 REC14 REC15 REC16 REC17 REC18 REC19 REC20
 ------*---------------------------------------------------------------------------------------------------------------------------
   0.   *   5.0   5.0   5.5   5.2   5.0   5.6   5.6   6.0   5.9   6.2   6.0   6.0   6.3   5.6   5.2   5.1   5.5   5.9   5.0   5.0
  10.   *   5.0   5.0   5.2   5.1   5.0   5.6   5.6   5.6   5.6   5.6   6.2   6.1   6.5   5.8   5.2   5.1   5.9   6.6   5.0   5.0
  20.   *   5.0   5.0   5.1   5.0   5.0   5.6   5.6   5.5   5.3   5.3   6.4   6.2   6.5   6.1   5.2   5.2   6.4   7.0   5.2   5.0
  30.   *   5.0   5.0   5.0   5.0   5.0   5.5   5.6   5.6   5.3   5.3   6.6   6.3   6.2   6.4   5.4   5.2   6.7   7.0   5.4   5.0
  40.   *   5.0   5.0   5.0   5.0   5.0   5.4   5.6   5.7   5.3   5.2   6.6   6.5   6.1   6.4   5.7   5.4   6.8   6.8   5.6   5.2
  50.   *   5.0   5.0   5.0   5.0   5.0   5.3   5.6   5.7   5.3   5.1   6.3   6.5   6.0   6.1   6.0   5.5   6.7   6.5   5.8   5.3
  60.   *   5.0   5.0   5.0   5.0   5.0   5.1   5.6   5.7   5.1   5.0   5.8   6.6   6.1   6.0   6.0   5.8   6.7   6.3   5.8   5.5
  70.   *   5.0   5.0   5.0   5.0   5.0   5.0   5.3   5.6   5.0   5.0   5.5   6.6   6.2   6.0   5.9   6.1   6.6   5.9   5.7   5.5
  80.   *   5.0   5.0   5.1   5.0   5.0   5.0   5.2   5.4   5.0   5.0   5.4   6.5   6.0   5.9   6.0   6.3   6.6   5.9   5.7   5.5
  90.   *   5.0   5.1   5.3   5.0   5.0   5.0   5.0   5.2   5.0   5.0   5.4   6.3   6.0   5.8   5.7   6.6   6.7   6.1   5.9   5.6
 100.   *   5.1   5.4   5.5   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.3   6.2   5.9   5.7   5.4   6.5   6.7   6.2   5.8   5.7
 110.   *   5.2   5.6   5.8   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.2   6.1   6.0   5.7   5.4   6.6   6.8   6.2   5.8   5.8
 120.   *   5.4   5.8   5.8   5.2   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.9   6.2   5.7   5.2   6.8   7.0   6.1   6.0   6.0
 130.   *   5.6   5.8   5.8   5.3   5.1   5.0   5.0   5.0   5.0   5.0   5.1   5.7   6.4   5.4   5.1   6.9   7.0   6.0   6.0   5.9
 140.   *   5.6   5.8   5.7   5.4   5.2   5.0   5.0   5.0   5.0   5.0   5.1   5.6   6.4   5.3   5.0   7.2   7.0   6.2   6.0   5.5
 150.   *   5.6   5.7   5.7   5.4   5.3   5.0   5.0   5.0   5.0   5.0   5.1   5.4   6.3   5.1   5.0   7.2   6.9   6.3   6.0   5.2
 160.   *   5.7   5.7   5.5   5.3   5.3   5.0   5.0   5.1   5.0   5.0   5.0   5.4   6.0   5.0   5.0   7.1   6.7   6.3   5.8   5.2
 170.   *   5.7   5.7   5.6   5.6   5.5   5.0   5.0   5.2   5.0   5.0   5.0   5.3   5.6   5.0   5.0   6.8   6.4   6.1   5.5   5.2
 180.   *   5.7   5.7   6.0   5.8   5.8   5.0   5.0   5.6   5.1   5.0   5.0   5.2   5.3   5.0   5.0   6.2   5.9   5.8   5.5   5.2
 190.   *   5.7   5.7   6.3   6.1   6.1   5.0   5.0   6.1   5.2   5.0   5.0   5.1   5.1   5.0   5.0   5.6   5.4   5.5   5.5   5.2
 200.   *   5.7   5.9   6.3   6.1   6.3   5.0   5.0   6.6   5.3   5.0   5.0   5.0   5.1   5.0   5.0   5.3   5.4   5.5   5.4   5.2
 210.   *   5.8   6.2   6.2   6.2   6.7   5.0   5.2   6.9   5.4   5.0   5.0   5.0   5.0   5.0   5.0   5.2   5.3   5.5   5.3   5.2
 220.   *   6.0   6.3   5.9   6.3   6.6   5.0   5.4   6.8   5.5   5.1   5.0   5.0   5.0   5.0   5.0   5.1   5.2   5.6   5.3   5.2
 230.   *   6.2   6.2   5.9   6.4   6.6   5.2   5.5   6.6   5.7   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.7   5.3   5.2
 240.   *   6.2   6.1   6.2   6.4   6.3   5.3   5.8   6.4   6.0   5.1   5.0   5.0   5.0   5.0   5.0   5.0   5.1   5.6   5.2   5.1
 250.   *   6.2   5.9   6.0   6.3   6.2   5.5   5.8   6.1   6.1   5.2   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.5   5.2   5.1
 260.   *   5.9   5.7   6.0   6.2   6.2   5.5   5.7   5.9   6.4   5.3   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.3   5.1   5.0
 270.   *   5.8   5.6   5.9   6.3   6.3   5.7   5.7   5.8   6.6   5.4   5.0   5.0   5.2   5.1   5.0   5.0   5.0   5.1   5.1   5.0
 280.   *   5.4   5.6   5.8   6.2   6.0   5.7   5.7   5.9   6.6   5.4   5.0   5.0   5.4   5.1   5.0   5.0   5.0   5.0   5.0   5.0
 290.   *   5.5   5.7   6.0   6.2   5.9   5.9   5.7   5.9   6.6   5.4   5.0   5.0   5.7   5.2   5.1   5.0   5.0   5.0   5.0   5.0
 300.   *   5.5   5.7   6.2   6.2   5.6   6.0   5.9   5.9   6.8   5.6   5.0   5.1   5.8   5.3   5.1   5.0   5.0   5.0   5.0   5.0
 310.   *   5.4   5.7   6.4   6.3   5.5   6.0   6.1   6.0   6.8   6.0   5.0   5.2   5.8   5.3   5.2   5.0   5.0   5.0   5.0   5.0
 320.   *   5.2   5.5   6.5   6.2   5.3   6.0   6.2   6.1   6.9   6.4   5.1   5.2   5.7   5.4   5.2   5.0   5.0   5.0   5.0   5.0
 330.   *   5.0   5.3   6.5   6.0   5.2   5.8   6.2   6.5   6.9   6.8   5.2   5.3   5.6   5.5   5.2   5.0   5.0   5.1   5.0   5.0
 340.   *   5.0   5.1   6.3   5.7   5.2   5.6   6.0   6.5   6.6   6.9   5.3   5.3   5.5   5.6   5.2   5.0   5.1   5.1   5.0   5.0
 350.   *   5.0   5.0   5.9   5.5   5.1   5.6   5.7   6.3   6.2   6.5   5.5   5.6   5.8   5.6   5.2   5.0   5.2   5.4   5.0   5.0
 360.   *   5.0   5.0   5.5   5.2   5.0   5.6   5.6   6.0   5.9   6.2   6.0   6.0   6.3   5.6   5.2   5.1   5.5   5.9   5.0   5.0
 ------*---------------------------------------------------------------------------------------------------------------------------
 MAX    *   6.2   6.3   6.5   6.4   6.7   6.0   6.2   6.9   6.9   6.9   6.6   6.6   6.5   6.4   6.0   7.2   7.0   7.0   6.0   6.0
 DEGR.  *   230   220   320   230   210   300   320   210   320   340    30    60    10    30    50   140   120    20   120   120

 THE HIGHEST CONCENTRATION OF    7.20 PPM OCCURRED AT RECEPTOR REC16.
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Microscale Results Summary

1 Hour CO Results

Highest values for specific receptors are in bold

			Year	
		1998	2010	
Receptor Location	**Intersection/Receptors**	**Existing**	**No Build**	**Build**
North Easton Station	Route 138 (Washington St) and Main St.			
Northeast Quadrant **Hilliards House of Candy**	Recp 1	7.3	6.1	6.2
	Recp 2	7.7	6.2	6.3
	Recp 3	7.4	6.2	6.5
	Recp 4	7.7	6.3	6.4
	Recp 5	**7.5**	**6.2**	**6.7**
Southeast Quadrant **Open space/** **Stonehill College**	Recp 6	6.9	5.9	6.0
	Recp 7	6.9	6.0	6.2
	Recp 8	8.8	6.7	6.9
	Recp 9	**9.0**	**6.9**	**6.9**
	Recp 10	8.1	6.5	6.9
Southwest Quadrant **307 Main St** **residence**	Recp 11	7.7	6.4	6.6
	Recp 12	**8.2**	**6.5**	**6.6**
	Recp 13	7.8	6.3	6.5
	Recp 14	7.6	6.2	6.4
	Recp 15	6.6	5.8	6.0
Northwest Quadrant **North Easton Village Shops**	Recp 16	7.8	6.4	7.2
	Recp 17	**9.1**	**6.9**	**7.0**
	Recp 18	8.4	6.6	7.0
	Recp 19	7.1	6.0	6.0
	Recp 20	6.7	5.7	6.0
Raynham Station	Route 138 (Turnpike St) and Route 106 (Foundry St)			
Northeast Quadrant **Citgo Gas Station/** **7-Eleven Store**	Recp 1	9.3	6.8	6.8
	Recp 2	**9.9**	**7.1**	**7.0**
	Recp 3	9.2	6.7	6.7
	Recp 4	7.6	6.3	6.3
	Recp 5	7.3	6.3	6.3
Southeast Quadrant **Open space**	Recp 6	8.5	6.6	6.6
	Recp 7	8.7	6.7	6.7
	Recp 8	8.5	6.6	6.6
	Recp 9	**9.0**	**6.8**	**6.8**
	Recp 10	7.8	6.6	6.6
Southwest Quadrant **Hillside Buildings** **479 Turnpike St**	Recp 11	7.9	6.3	6.3
	Recp 12	**8.7**	**6.6**	**6.6**
	Recp 13	8.2	6.4	6.4
	Recp 14	8.2	6.6	6.6
	Recp 15	7.3	6.2	6.2
Northwest Quadrant **Open Space**	Recp 16	7.8	6.8	6.8
	Recp 17	**9.6**	**7.2**	**7.2**
	Recp 18	8.2	6.8	6.8
	Recp 19	7.7	6.3	6.3
	Recp 20	7.1	6.2	6.1

		Year		
		1998	2010	
Receptor Location	**Intersection/Receptors**	**Existing**	**No Build**	**Build**
Dean St. Station Taunton	Route 44 (Dean St) and Longmeadow Road			
Northeast Quadrant 94 Dean St residence	**Recp 1**	**9.9**	**7.3**	**7.4**
	Recp 2	9.8	7.3	7.3
	Recp 3	9.2	6.9	6.9
	Recp 4	8.2	6.5	6.5
	Recp 5	7.2	6.1	6.1
Southeast Quadrant Open Space	Recp 6	8.4	6.6	6.6
	Recp 7	8.2	6.6	6.6
	Recp 8	**8.8**	**6.8**	**6.8**
	Recp 9	8.2	6.7	6.7
	Recp 10	7.3	6.1	6.1
Southwest Quadrant Open space	Recp 11	7.3	6.3	6.3
	Recp 12	8.3	6.7	6.7
	Recp 13	9.0	7.0	7.0
	Recp 14	9.2	6.9	6.9
	Recp 15	**9.3**	**7.0**	**7.1**
Northwest Quadrant 88 Dean St residence	Recp 16	7.3	6.3	6.3
	Recp 17	**9.0**	**7.1**	**7.1**
	Recp 18	9.0	7.0	7.0
	Recp 19	8.4	6.8	6.8
	Recp 20	8.2	6.6	6.7

8 Hour CO Results

Highest values for specific receptors are in bold

		Year		
		1998	2010	
Receptor Location	**Intersection/Receptors**	**Existing**	**No Build**	**Build**
North Easton Station	Route 138 (Washington St) and Main St.			
Northeast Quadrant Hilliards House of Candy	Recp 1	4.8	4.0	4.1
	Recp 2	5.1	4.1	4.2
	Recp 3	4.9	4.1	4.3
	Recp 4	5.1	4.2	4.2
	Recp 5	**5.0**	**4.1**	**4.4**
Southeast Quadrant Open space/ Stonehill College	Recp 6	4.6	3.9	4.0
	Recp 7	4.6	4.0	4.1
	Recp 8	5.8	4.4	4.6
	Recp 9	**5.9**	**4.6**	**4.6**
	Recp 10	5.3	4.3	4.6
Southwest Quadrant 307 Main St residence	Recp 11	5.1	4.2	4.4
	Recp 12	**5.4**	**4.3**	**4.4**
	Recp 13	5.1	4.2	4.3
	Recp 14	5.0	4.1	4.2
	Recp 15	4.4	3.8	4.0
Northwest Quadrant North Easton Village Shops	Recp 16	5.1	4.2	4.8
	Recp 17	**6.0**	**4.6**	**4.6**
	Recp 18	5.5	4.4	4.6
	Recp 19	4.7	4.0	4.0
	Recp 20	4.4	3.8	4.0
Raynham Station	Route 138 (Turnpike St) and Route 106 (Foundry St)			
Northeast Quadrant Citgo Gas Station/ 7-Eleven Store	Recp 1	6.1	4.5	4.5
	Recp 2	**6.5**	**4.7**	**4.6**
	Recp 3	6.1	4.4	4.4
	Recp 4	5.0	4.2	4.2
	Recp 5	4.8	4.2	4.2
Southeast Quadrant Open space	Recp 6	5.6	4.4	4.4
	Recp 7	5.7	4.4	4.4
	Recp 8	5.6	4.4	4.4
	Recp 9	**5.9**	**4.5**	**4.5**
	Recp 10	5.1	4.4	4.4
Southwest Quadrant Hillside Buildings 479 Turnpike St	Recp 11	5.2	4.2	4.2
	Recp 12	**5.7**	**4.4**	**4.4**
	Recp 13	5.4	4.2	4.2
	Recp 14	5.4	4.4	4.4
	Recp 15	4.8	4.1	4.1
Northwest Quadrant Open Space	Recp 16	5.1	4.5	4.5
	Recp 17	**6.3**	**4.8**	**4.8**
	Recp 18	5.4	4.5	4.5
	Recp 19	5.1	4.2	4.2
	Recp 20	4.7	4.1	4.0

Receptor Location	Intersection/Receptors	Year 1998 Existing	 2010 No Build	 Build
Dean St. Station Taunton	Route 44 (Dean St) and Longmeadow Road			
Northeast Quadrant 94 Dean St residence	**Recp 1**	**6.5**	**4.8**	**4.9**
	Recp 2	6.5	4.8	4.8
	Recp 3	6.1	4.6	4.6
	Recp 4	5.4	4.3	4.3
	Recp 5	4.8	4.0	4.0
Southeast Quadrant Open Space	Recp 6	5.5	4.4	4.4
	Recp 7	5.4	4.4	4.4
	Recp 8	**5.8**	**4.5**	**4.5**
	Recp 9	5.4	4.4	4.4
	Recp 10	4.8	4.0	4.0
Southwest Quadrant Open space	Recp 11	4.8	4.2	4.2
	Recp 12	5.5	4.4	4.4
	Recp 13	5.9	4.6	4.6
	Recp 14	6.1	4.6	4.6
	Recp 15	**6.1**	**4.6**	**4.7**
Northwest Quadrant 88 Dean St residence	Recp 16	4.8	4.2	4.2
	Recp 17	**5.9**	**4.7**	**4.7**
	Recp 18	5.9	4.6	4.6
	Recp 19	5.5	4.5	4.5
	Recp 20	5.4	4.4	4.4

Mesoscale Analysis

Locomotive Emission Calculation Sheet & Summary

Fuel Rate=	2	Gals/Mile
Numer of Train Trips =	20	Per Line

	Line #1		Line #2		Fuel Use		Line #1 Train Emissions (Line Haul)			
Station	Mile Post	Distance	Mile Post	Distance	Line #1 (gal/day)	Line #2 (gal/day)	VOC (kg/day)	CO (kg/day)	NOx (kg/day)	PM (kg/day)
New Bedford		--		--	--	--	--	--	--	--
Fall River		--	NA	--	--	--	--	--	--	--
Freetown		6.0	NA	--	240	--	2	5	57	1
Myricks Jct.	39.7	4.7		14.0	188	560	1	4	45	1
Taunton, East	35.6	4.0		4.0	160	160	1	3	38	1
Taunton, Dean Street	33.3	2.3		2.3	92	92	1	2	22	0
Raynham	28.7	4.6		4.6	184	184	1	4	44	1
North Easton	21.2	7.5		7.5	300	300	2	6	71	1
Stoughton	18.8	6.4		6.4	256	256	2	5	61	1
Canton Jct.	14.8	4.0		4.0	160	160	1	3	38	1
Boston	0.0	14.8		14.8	592	592	4	12	141	2
Total		**54.3**		**57.6**	**2172**	**2304**	**16**	**45**	**516**	**7**

Line #2 Train Emissions (Line Haul)

VOC (kg/day)	CO (kg/day)	NOx (kg/day)	PM (kg/day)
--	--	--	--
--	--	--	--
--	--	--	--
4	12	133	2
1	3	38	1
1	2	22	0
1	4	44	1
2	6	71	1
2	5	61	1
1	3	38	1
4	12	141	2
17	**48**	**547**	**7**

Train Em. Factor

Pollutant	Idle (g/hr)	Haul (lb/gal)	Haul (g/gal)
VOC	601	0.0160	7.2576
CO	1532	0.0460	20.8656
NOx	8716	0.5236	237.5050
PM	44	0.0071	3.2206

Train Fuel Use

Average locomotive fuel use calculations based on Train Performance Simulator (TPSD) analysis from proposed Boston-Portland Maine Rail project. Analysis assumes F40P type engine, and includes fuel consumption during station pick-up/drop-off idle. Average fuel consumption from analysis was approx. 1.5 gal/Mi.. For purposes of this analysis, assume fuel use of 2.0 gal/Mi.

Total Train Emissions (Line Haul)

VOC (kg/day)	CO (kg/day)	NOx (kg/day)	PM (kg/day)
--	--	--	--
--	--	--	--
2	5	57	1
5	16	178	2
2	7	76	1
1	4	44	1
3	8	87	1
4	13	143	2
4	11	122	2
2	7	76	1
9	25	281	4
32	**93**	**1063**	**14**

Idle Emissions Summary

No. Trains: 9
Idle Period (Min): 45

	VOC (kg/day)	CO (kg/day)	NOx (kg/day)	PM (kg/day)
Total:	4	10	59	0.3

Total Train Emissions (Line Haul + Idle)

VOC (kg/day)	CO (kg/day)	NOx (kg/day)	PM (kg/day)
37	104	1122	15

1998	**Veh. Emissions**	**308**	**5034**	**503**
	Em. Savings (Increase)	-272	-4930	619
2010	**Veh. Emissions**	**136**	**1881**	**284**
	Em. Savings (Increase)	-100	-1777	838

New Bedford/Fall River Rail Project
Commuter Travel Characteristics Calculation (VMT)
1998

			Speed		Vehicles			VMT		
Station	**Route**	**Miles**	**Peak**	**Off-Peak**	**Daily**	**Peak**	**Off-Peak**	**Daily**	**Peak**	**Off-Peak**
Fall River	79/24	18	50	60	1000	650	350	18,411	11,967	6,444
		16	45	60	1000	650	350	16,150	10,498	5,653
	128	4	40	60	1000	650	350	3,876	2,519	1,357
	93	9	35	50	1000	650	350	9,044	5,879	3,165
							Subtotal:	47,481	30,863	16,618
Freetown	24	6	50	50	1000	650	350	6,137	3,989	2,148
		24	45	50	1000	650	350	23,579	15,326	8,253
	128	4	40	50	1000	650	350	3,876	2,519	1,357
	93	9	35	50	1000	650	350	9,044	5,879	3,165
							Subtotal:	42,636	27,713	14,923
New Bedford	140	17	35	40	1900	1235	665	33,140	21,541	11,599
	24	5	50	60	1900	1235	665	10,433	6,781	3,652
		18	40	60	1900	1235	665	33,754	21,940	11,814
	128	4	40	60	1900	1235	665	7,364	4,787	2,578
	93	9	35	50	1900	1235	665	17,184	11,169	6,014
							Subtotal:	101,874	66,218	35,656
E. Taunton	24	5	50	60	1900	1235	665	10,433	6,781	3,652
		18	40	60	1900	1235	665	33,754	21,940	11,814
	128	4	40	60	1900	1235	665	7,364	4,787	2,578
	93	9	35	50	1900	1235	665	17,184	11,169	6,014
							Subtotal:	68,734	44,677	24,057
Taunton	Sr-24	20	50	60	364	218	145	7273	4364	2909
Dean Street	I-93	13	40	60	364	218	145	4727	2836	1891
							Subtotal:	12,000	7,200	4,800
Raynham	I-495	3	50	60	273	164	109	764	458	305
	Sr 24	19	45	60	273	164	109	5073	3044	2029
	I-93	13	40	60	273	164	109	3545	2127	1418
							Subtotal:	9,382	5,629	3,753
North Easton	Rt. 138	7	30	40	1000	600	400	6,700	4,020	2,680
	I-93	15	40	60	1000	600	400	14,600	8,760	5,840
							Subtotal:	21,300	12,780	8,520
							Total	**303,407**	**195,081**	**108,327**

New Bedford/Fall River Rail Project
Commuter Travel Emissions Calculation (Kg/day)
1998

VOC		VOC			CO		CO			NOx		NOx		
Emission Factors		Emissions			Emission Factors		Emissions			Emission Factors		Emissions		
Peak	Off-Peak	Peak	Off-Peak	Total	Peak	Off-Peak	Peak	Off-Peak	Total	Peak	Off-Peak	Peak	Off-Peak	Total
0.9	0.99	11	6	17	13.1	20.33	157	131	288	1.62	2.13	19	14	33
0.95	0.99	10	6	16	14.04	20.33	147	115	262	1.51	2.13	16	12	28
1.04	0.99	3	1	4	15.92	20.33	40	28	68	1.5	2.13	4	3	7
1.16	0.9	7	3	10	18.35	13.1	108	41	149	1.49	1.62	9	5	14
	Subtotal:	30	16	46		Subtotal:	452	315	767		Subtotal:	48	34	82
0.9	0.9	4	2	6	13.1	13.1	52	28	80	1.62	1.62	6	3	10
0.95	0.9	15	7	22	14.04	13.1	215	108	323	1.51	1.62	23	13	37
1.04	0.9	3	1	4	15.92	13.1	40	18	58	1.5	1.62	4	2	6
1.16	0.9	7	3	10	18.35	13.1	108	41	149	1.49	1.62	9	5	14
	Subtotal:	28	13	41		Subtotal:	415	195	611		Subtotal:	42	24	66
1.16	1.04	25	12	37	18.35	15.92	395	185	580	1.49	1.5	32	17	49
0.9	0.99	6	4	10	13.1	20.33	89	74	163	1.62	2.13	11	8	19
1.04	0.99	23	12	35	15.92	20.33	349	240	589	1.5	2.13	33	25	58
1.04	0.99	5	3	8	15.92	20.33	76	52	129	1.5	2.13	7	5	13
1.16	0.9	13	5	18	18.35	13.1	205	79	284	1.49	1.62	17	10	26
	Subtotal:	72	35	107		Subtotal:	1115	630	1745		Subtotal:	100	66	165
0.9	0.99	6	4	10	13.1	20.33	89	74	163	1.62	2.13	11	8	19
1.04	0.99	23	12	35	15.92	20.33	349	240	589	1.5	2.13	33	25	58
1.04	0.99	5	3	8	15.92	20.33	76	52	129	1.5	2.13	7	5	13
1.16	0.9	13	5	18	18.35	13.1	205	79	284	1.49	1.62	17	10	26
	Subtotal:	47	23	70		Subtotal:	719	446	1165		Subtotal:	68	48	116
0.9	0.99	4	3	7	13.1	20.33	57	59	116	1.62	2.13	7	6	13
1.04	0.99	3	2	5	15.92	20.33	45	38	84	1.5	2.13	4	4	8
	Subtotal:	7	5	12		Subtotal:	102	98	200		Subtotal:	11	10	22
0.9	0.99	0	0	1	13.1	20.33	6	6	12	1.62	2.13	1	1	1
0.95	0.99	3	2	5	14.04	20.33	43	41	84	1.51	2.13	5	4	9
1.04	0.99	2	1	4	15.92	20.33	34	29	63	1.5	2.13	3	3	6
	Subtotal:	6	4	9		Subtotal:	83	76	159		Subtotal:	9	8	17
1.3	1.04	5	3	8	21.61	15.92	87	43	130	1.47	1.5	6	4	10
1.04	0.99	9	6	15	15.92	20.33	139	119	258	1.5	2.13	13	12	26
	Subtotal:	14	9	23		Subtotal:	226	161	388		Subtotal:	19	16	36
	Total	**203**	**105**	**308**		**Total**	**3,113**	**1,922**	**5,034**		**Total**	**296**	**206**	**503**

New Bedford/Fall River Rail Project
Commuter Travel Characteristics Calculation (VMT)
2010

			Speed		Vehicles				VMT	
Station	**Route**	**Miles**	**Peak**	**Off-Peak**	**Daily**	**Peak**	**Off-Peak**	**Daily**	**Peak**	**Off-Peak**
Fall River	79/24	18	50	60	1000	650	350	18,411	11,967	6,444
		16	45	60	1000	650	350	16,150	10,498	5,653
	128	4	40	60	1000	650	350	3,876	2,519	1,357
	93	9	35	50	1000	650	350	9,044	5,879	3,165
							Subtotal:	47,481	30,863	16,618
Freetown	24	6	50	50	1000	650	350	6,137	3,989	2,148
		24	45	50	1000	650	350	23,579	15,326	8,253
	128	4	40	50	1000	650	350	3,876	2,519	1,357
	93	9	35	50	1000	650	350	9,044	5,879	3,165
							Subtotal:	42,636	27,713	14,923
New Bedford	140	17	35	40	1900	1235	665	33,140	21,541	11,599
	24	5	50	60	1900	1235	665	10,433	6,781	3,652
		18	40	60	1900	1235	665	33,754	21,940	11,814
	128	4	40	60	1900	1235	665	7,364	4,787	2,578
	93	9	35	50	1900	1235	665	17,184	11,169	6,014
							Subtotal:	101,874	66,218	35,656
E. Taunton	24	5	50	60	1900	1235	665	10,433	6,781	3,652
		18	40	60	1900	1235	665	33,754	21,940	11,814
	128	4	40	60	1900	1235	665	7,364	4,787	2,578
	93	9	35	50	1900	1235	665	17,184	11,169	6,014
							Subtotal:	68,734	44,677	24,057
Taunton	Sr-24	20	50	60	364	218	145.4545	7,273	4,364	2,909
Dean Street	I-93	13	40	60	364	218	145.4545	4,727	2,836	1,891
							Subtotal:	12,000	7,200	4,800
Raynham	I-495	3	50	60	273	164	109.0909	764	458	305
	Sr 24	19	45	60	273	164	109.0909	5,073	3,044	2,029
	I-93	13	40	60	273	164	109.0909	3,545	2,127	1,418
							Subtotal:	9,382	5,629	3,753
North Easton	Rt. 138	7	30	40	1000	600	400	6,700	4,020	2,680
	I-93	15	40	60	1000	600	400	14,600	8,760	5,840
					364	218				
					364	218	Subtotal:	21,300	12,780	8,520
							Total	**303,407**	**195,081**	**108,327**

New Bedford/Fall River Rail Project
Commuter Travel Emissions Calculation (Kg/day)
2010

VOC		VOC			CO		CO			NOx		NOx		
Emission Factors			Emissions		Emission Factors			Emissions		Emission Factors			Emissions	
Peak	Off-Peak	Peak	Off-Peak	Total	Peak	Off-Peak	Peak	Off-Peak	Total	Peak	Off-Peak	Peak	Off-Peak	Total
0.4	0.44	5	3	8	4.7	6.81	56	44	100	0.92	1.17	11	8	19
0.42	0.44	4	2	7	5.21	6.81	55	38	93	0.87	1.17	9	7	16
0.46	0.44	1	1	2	6.21	6.81	16	9	25	0.86	1.17	2	2	4
0.51	0.4	3	1	4	7.51	4.7	44	15	59	0.85	0.92	5	3	8
	Subtotal:	13	7	21		Subtotal:	171	106	277		Subtotal:	27	19	46
0.4	0.4	2	1	2	4.7	4.7	19	10	29	0.92	0.92	4	2	6
0.42	0.4	6	3	10	5.21	4.7	80	39	119	0.87	0.92	13	8	21
0.46	0.4	1	1	2	6.21	4.7	16	6	22	0.86	0.92	2	1	3
0.51	0.4	3	1	4	7.51	4.7	44	15	59	0.85	0.92	5	3	8
	Subtotal:	12	6	18		Subtotal:	158	70	229		Subtotal:	24	14	38
0.51	0.46	11	5	16	7.51	6.21	162	72	234	0.85	0.86	18	10	28
0.4	0.44	3	2	4	4.7	6.81	32	25	57	0.92	1.17	6	4	11
0.46	0.44	10	5	15	6.21	6.81	136	80	217	0.86	1.17	19	14	33
0.46	0.44	2	1	3	6.21	6.81	30	18	47	0.86	1.17	4	3	7
0.51	0.4	6	2	8	7.51	4.7	84	28	112	0.85	0.92	9	6	15
	Subtotal:	32	16	47		Subtotal:	443	223	667		Subtotal:	57	37	94
0.4	0.44	3	2	4	4.7	6.81	32	25	57	0.92	1.17	6	4	11
0.46	0.44	10	5	15	6.21	6.81	136	80	217	0.86	1.17	19	14	33
0.46	0.44	2	1	3	6.21	6.81	30	18	47	0.86	1.17	4	3	7
0.51	0.4	6	2	8	7.51	4.7	84	28	112	0.85	0.92	9	6	15
	Subtotal:	21	10	31		Subtotal:	282	151	433		Subtotal:	39	27	65
0.4	0.44	2	1	3	4.7	6.81	21	20	40	0.92	1.17	4	3	7
0.46	0.44	1	1	2	6.21	6.81	18	13	30	0.86	1.17	2	2	5
	Subtotal:	3	2	5		Subtotal:	38	33	71		Subtotal:	6	6	12
0.4	0.44	0	0	0	4.7	6.81	2	2	4	0.92	1.17	0	0	1
0.42	0.44	1	1	2	5.21	6.81	16	14	30	0.87	1.17	3	2	5
0.46	0.44	1	1	2	6.21	6.81	13	10	23	0.86	1.17	2	2	3
	Subtotal:	2	2	4		Subtotal:	31	26	57		Subtotal:	5	4	9
0.57	0.46	2	1	4	9.24	6.21	37	17	54	0.84	0.86	3	2	6
0.46	0.44	4	3	7	6.21	6.81	54	40	94	0.86	1.17	8	7	14
	Subtotal:	6	4	10		Subtotal:	92	56	148		Subtotal:	11	9	20
	Total	**90**	**47**	**136**		**Total**	**1,215**	**666**	**1,881**		**Total**	**169**	**115**	**284**

Year 1998 Emission Factor Summary, LDGV Vehicles Only

	Emission Factor (g/mi)		
Speed	VOC	CO	NOx
2.5	10.80	162.68	2.11
	8.80	138.23	1.97
4	6.48	107.52	1.80
5	5.19	89.00	1.70
6	4.37	76.62	1.64
7	3.81	67.77	1.59
8	3.47	61.13	1.55
9	3.21	55.97	1.52
10	2.99	51.85	1.50
11	2.80	48.48	1.48
12	2.63	45.67	1.47
13	2.49	43.30	1.46
14	2.36	41.27	1.44
15	2.23	39.51	1.44
16	2.12	37.97	1.43
17	2.02	36.61	1.42
18	1.92	35.40	1.41
19	1.83	34.32	1.41
20	1.75	32.97	1.41
21	1.69	31.35	1.42
22	1.63	29.88	1.43
23	1.58	28.53	1.43
24	1.53	27.30	1.44
25	1.49	26.16	1.45
26	1.44	25.11	1.45
27	1.41	24.14	1.46
28	1.37	23.23	1.46
29	1.33	22.39	1.47
30	1.30	21.61	1.47
31	1.27	20.87	1.47
32	1.24	20.18	1.48
33	1.21	19.53	1.48
34	1.18	18.92	1.48
35	1.16	18.35	1.49
36	1.13	17.81	1.49
37	1.11	17.30	1.49
38	1.09	16.81	1.50
39	1.07	16.35	1.50
40	1.04	15.92	1.50
41	1.02	15.50	1.50
42	1.00	15.11	1.51
43	0.99	14.73	1.51
44	0.97	14.38	1.51
45	0.95	14.04	1.51
46	0.93	13.71	1.51
47	0.92	13.40	1.52
48	0.90	13.10	1.52
49	0.90	13.10	1.57
50	0.90	13.10	1.62
51	0.89	13.10	1.67
52	0.89	13.10	1.72
53	0.89	13.10	1.77
54	0.89	13.10	1.82
55	0.89	13.10	1.87
56	0.91	14.55	1.92
57	0.93	15.99	1.97
58	0.95	17.44	2.02
59	0.97	18.88	2.08
60	0.99	20.33	2.13
61	1.01	21.77	2.18
62	1.03	23.22	2.23
63	1.05	24.66	2.28
64	1.07	26.11	2.33
65	1.09	27.56	2.38

Year 2010 Emission Factor Summary, LDGV Vehicles Only

	Emission Factor (g/mi)		
Speed	VOC	CO	NOx
2.5	4.28	68.17	1.21
3	3.47	58.15	1.13
4	2.55	45.63	1.04
5	2.05	38.11	0.98
6	1.74	33.10	0.94
7	1.52	29.53	0.91
8	1.39	26.84	0.89
9	1.29	24.76	0.87
10	1.21	23.09	0.86
11	1.14	21.72	0.85
12	1.08	20.58	0.84
13	1.03	19.62	0.83
14	0.98	18.79	0.83
15	0.94	18.08	0.82
16	0.90	17.45	0.82
17	0.87	16.90	0.81
18	0.84	16.41	0.81
19	0.82	15.97	0.81
20	0.78	15.30	0.81
21	0.75	14.43	0.81
22	0.73	13.64	0.82
23	0.70	12.93	0.82
24	0.68	12.27	0.83
25	0.66	11.66	0.83
26	0.64	11.10	0.83
27	0.62	10.59	0.84
28	0.60	10.11	0.84
29	0.59	9.66	0.84
30	0.57	9.24	0.84
31	0.56	8.85	0.85
32	0.55	8.48	0.85
33	0.53	8.14	0.85
34	0.52	7.82	0.85
35	0.51	7.51	0.85
36	0.50	7.22	0.86
37	0.49	6.95	0.86
38	0.48	6.69	0.86
39	0.47	6.45	0.86
40	0.46	6.21	0.86
41	0.45	5.99	0.86
42	0.45	5.78	0.86
43	0.44	5.58	0.87
44	0.43	5.39	0.87
45	0.42	5.21	0.87
46	0.42	5.03	0.87
47	0.41	4.86	0.87
48	0.40	4.70	0.87
49	0.40	4.70	0.90
50	0.40	4.70	0.92
51	0.40	4.70	0.95
52	0.40	4.70	0.97
53	0.40	4.70	1.00
54	0.40	4.70	1.02
55	0.40	4.70	1.05
56	0.41	5.12	1.07
57	0.41	5.54	1.10
58	0.42	5.97	1.12
59	0.43	6.39	1.15
60	0.44	6.81	1.17
61	0.45	7.23	1.20
62	0.46	7.65	1.22
63	0.47	8.08	1.25
64	0.47	8.50	1.27
65	0.48	8.92	1.30

NOISE APPENDIX

- Summary of Modeled Noise Levels
- Impacted Building Counts
- School Sites
- FTA Transit Noise Assessment Worksheets

Summary of Modeled Noise Levels

New Bedford/Fall River Modeled Noise Levels

	Milepost	Crossing Type - Grade, Overhead, Underground, Station	Horn Noise	Speed Used	Building Offset (ft.)	Leq					Ldn				
						Rail Project	Existing Road (Monitored)	Future No-Build	Build Condition	difference (Build - Existing) dbA	Rail Project	Existing (Monitored)	Future No-Build	Build Condition	difference (Build - Existing) dbA
1 Brock Street	4.30	G	Yes	30	75	65	**58**	**59**	66	8	66	**65**	**66**	69	4
2 Plain Street	4.60	G	Yes	30	75	60	**60**	**61**	64	4	61	**62**	**63**	65	3
3 Morton Street	5.20	G	Yes	30	100	58	**67**	**68**	69	1	59	**72**	**73**	73	1
North Easton Station	**6.40**	Sta.	No		1,200	47	**64**	**65**	65	1	47	**64**	**65**	65	1
4 Elm Street (MP 7.60)	7.60	G	Yes	30	75	60	**65**	**66**	67	2	61	**70**	**71**	71	1
5 Oliver Street	7.80	G	Yes	30	100	58	**63**	**64**	65	2	59	**63**	**64**	65	2
6 Pond Street	7.90	UG	No	30	100	58	**62**	**63**	64	2	59	**63**	**64**	65	2
7 Main Street	8.05	OH	No	40	75	62	**64**	**65**	66	3	62	**66**	**67**	69	2
8 Bridge Street	8.40	OH	No	50	75	63	**58**	**59**	65	7	64	**61**	**62**	66	5
9 Short Street	9.55	G	Yes	70	100	64	**63**	**64**	67	4	64	**67**	**68**	70	2
10 Depot Street/123	10.00	G	Yes	70	75	65	**67**	**68**	70	3	66	**69**	**70**	72	2
11 Purchase Street	10.20	G	Yes	70	300	56	**60**	**61**	63	2	57	**64**	**65**	65	2
12 Prospect Street	10.90	G	Yes	70	100	64	**55**	**56**	64	10	64	**62**	**63**	67	4
Raynham Station	**14.10**	Sta.	No		1,600	46	**65**	**66**	66	1	46	**65**	**66**	66	1
13 Elm Street (MP 15.40)	15.40	G	Yes	70	100	64	**58**	**59**	65	7	64	**61**	**62**	66	5
14 Carver Street	15.80	G	Yes	70	75	65	**56**	**57**	66	10	66	**62**	**63**	68	6
15 Route 138	16.40	G	Yes	70	75	65	**65**	**66**	69	4	66	**70**	**71**	72	2
16 Britton Street	16.50	G	Yes	70	75	65	**58**	**59**	66	9	66	**60**	**61**	67	7
17 King Phillip Street	17.10	G	Yes	70	100	64	**64**	**65**	67	3	64	**66**	**67**	69	3
18 Longmeadow Road	18.90	G	Yes	30	300	51	**61**	**62**	62	1	52	**69**	**70**	70	1
Dean Street Station	**19.20**	Sta.	No		600	52	**54**	**55**	57	3	52	**54**	**55**	57	3
19 Dean Street	19.40	G	Yes	30	75	60	**65**	**66**	67	2	61	**68**	**69**	70	2
20 Ingell Street	61.92	G	Yes	30	100	58	**59**	**60**	62	3	59	**66**	**67**	67	2
21 Hart Street	62.43	G	Yes	30	75	60	**65**	**66**	67	2	61	**68**	**69**	70	2

Impacted Building Counts

Segment	MP	No-build	Build	Severe - closer than (feet)	Quantity Severe	Moderate - closer than (feet)	Quantity Moderate
Brock Street	4.30	66	69	65	3	150	8
Plain Street	4.60	63	65	100	8	200	14
Morton Street	5.20	73	73	30	0	65	0
North Easton Station	**6.40**	65	65	75	0	175	0
Elm Street (MP 7.60)	7.60	71	71	45	0	100	10
Oliver Street	7.80	64	65	75	0	175	2
Pond Street	7.90	64	65	75	0	175	8
Main Street	8.05	67	69	55	6	135	15
Bridge Street	8.40	62	66	100	2	200	15
Short Street	9.55	68	70	55	0	135	5
Depot Street/123	10.00	70	72	45	0	100	1
Purchase Street	10.20	65	65	75	0	175	2
Prospect Street	10.90	63	67	100	0	200	2
Raynham Station	**14.10**	66	66	65	0	150	0
Elm Street (MP 15.40)	15.40	62	66	100	4	200	3
Carver Street	15.80	63	68	100	1	200	1
Route 138	16.40	71	72	45	0	100	4
Britton Street	16.50	61	67	115	4	225	4
King Phillip Street	17.10	67	69	55	4	135	3
Longmeadow Road	18.90	70	70	45	0	100	2
Dean Street Station	**19.20**	55	57	150	0	300	0
Dean Street	19.40	69	70	50	0	115	2
Ingell Street	61.92	67	67	55	0	135	0
Hart Street	62.43	69	70	50	0	115	6
Total					**32**		**107**

5921_runs_70mph
building counts

School Sites

School	Distance to Track (feet)	Leq (dBA) Existing Background Noise	No-Build	Project	Build	Impact
Jones School	1,400					
Kimball School	1,400					
Unionville School	3,200					
Stonehill College	5,500					
Parkview School	2,300					
Easton Jr. High School	3,100					
Ames Highschoo	3,100					
Holy Cross Seminary	4,000					
School building near Easton Center	1,700					
Southeastern Regional Vocational High School	**750**	**61**	**62**	**50**	**62**	**No Impact**
High School	3,200					
Pole School	2,000					
Summer Street School	**600**	**65**	**66**	**51**	**66**	**No Impact**

FTA Transit Noise Assessment Worksheets

Federal Transit Adminstration
General Transit Noise Assessment
Case: Brock Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	66	65	56
Source 1	64	63	55
Source 2	61	60	52
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	35	distance (ft)	35	
Daytime Hours	speed (mph)	30	speed (mph)	30	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	30	speed (mph)	30	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Plain Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	61	60	51
Source 1	59	58	50
Source 2	56	55	47
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	**Source 1**		**Source 2**		**Source 3**
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	75	distance (ft)	75	
Daytime Hours	speed (mph)	30	speed (mph)	30	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	30	speed (mph)	30	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	**Number**
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Morton Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	59	58	50
Source 1	57	57	48
Source 2	54	53	45
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY

Noise receiver land use category (1, 2 or 3) 2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	100	distance (ft)	100	
Daytime Hours	speed (mph)	30	speed (mph)	30	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	30	speed (mph)	30	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Elm Street MP 7.6

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	61	60	51
Source 1	59	58	50
Source 2	56	55	47
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	75	distance (ft)	75	
Daytime Hours	speed (mph)	30	speed (mph)	30	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	30	speed (mph)	30	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Oliver Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	59	58	50
Source 1	57	57	48
Source 2	54	53	45
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	100	distance (ft)	100	
Daytime Hours (7 AM - 10 PM)	speed (mph)	30	speed (mph)	30	
	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours (10 PM - 7 AM)	speed (mph)	30	speed (mph)	30	
	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Pond Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	59	58	50
Source 1	57	57	48
Source 2	54	53	45
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY

Noise receiver land use category (1, 2 or 3) 2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	**Source 1**		**Source 2**		**Source 3**
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	100	distance (ft)	100	
Daytime Hours	speed (mph)	30	speed (mph)	30	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	30	speed (mph)	30	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	**Number**
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Main Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	62	62	53
Source 1	60	60	51
Source 2	58	58	49
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	75	distance (ft)	75	
Daytime Hours	speed (mph)	40	speed (mph)	40	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	40	speed (mph)	40	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Bridge Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	64	63	54
Source 1	61	61	52
Source 2	60	60	51
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY

Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3	
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3		0
Dist. to receiver	distance (ft)	75	distance (ft)	75		
Daytime Hours	speed (mph)	50	speed (mph)	50		
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47		
	locos/train	1	cars/train	8		
Nighttime Hours	speed (mph)	50	speed (mph)	50		
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33		
	locos/train	1	cars/train	8		
Jointed Track?	Y/N	N	Y/N	N		
Embedded Track?	Y/N	Y	Y/N	Y		
Aerial Structure?	Y/N	N	Y/N	N		
Barrier Present?	Y/N	N	Y/N	N		
Intervening Rows of Buildings	number	0	number	0		

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Short Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	64	64	55
Source 1	61	60	52
Source 2	61	61	52
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	100	distance (ft)	100	
Daytime Hours	speed (mph)	70	speed (mph)	70	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	70	speed (mph)	70	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Depot Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	66	65	57
Source 1	63	62	53
Source 2	63	63	54
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY

Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	75	distance (ft)	75	
Daytime Hours	speed (mph)	70	speed (mph)	70	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	70	speed (mph)	70	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Purchase Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	57	56	48
Source 1	54	53	44
Source 2	54	54	45
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	300	distance (ft)	300	
Daytime Hours	speed (mph)	70	speed (mph)	70	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	70	speed (mph)	70	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Prospect Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	64	64	55
Source 1	61	60	52
Source 2	61	61	52
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	100	distance (ft)	100	
Daytime Hours	speed (mph)	70	speed (mph)	70	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	70	speed (mph)	70	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Elm Street MP 15.4

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	64	64	55
Source 1	61	60	52
Source 2	61	61	52
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY

Noise receiver land use category (1, 2 or 3) 2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	100	distance (ft)	100	
Daytime Hours	speed (mph)	70	speed (mph)	70	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	70	speed (mph)	70	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Carver Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	66	65	57
Source 1	63	62	53
Source 2	63	63	54
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3	
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3		0
Dist. to receiver	distance (ft)	75	distance (ft)	75		
Daytime Hours	speed (mph)	70	speed (mph)	70		
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47		
	locos/train	1	cars/train	8		
Nighttime Hours	speed (mph)	70	speed (mph)	70		
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33		
	locos/train	1	cars/train	8		
Jointed Track?	Y/N	N	Y/N	N		
Embedded Track?	Y/N	Y	Y/N	Y		
Aerial Structure?	Y/N	N	Y/N	N		
Barrier Present?	Y/N	N	Y/N	N		
Intervening Rows of Buildings	number	0	number	0		

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Route 138

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	66	65	57
Source 1	63	62	53
Source 2	63	63	54
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	75	distance (ft)	75	
Daytime Hours	speed (mph)	70	speed (mph)	70	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	70	speed (mph)	70	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Britton Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	66	65	57
Source 1	63	62	53
Source 2	63	63	54
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3	
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3		0
Dist. to receiver	distance (ft)	75	distance (ft)	75		
Daytime Hours	speed (mph)	70	speed (mph)	70		
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47		
	locos/train	1	cars/train	8		
Nighttime Hours	speed (mph)	70	speed (mph)	70		
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33		
	locos/train	1	cars/train	8		
Jointed Track?	Y/N	N	Y/N	N		
Embedded Track?	Y/N	Y	Y/N	Y		
Aerial Structure?	Y/N	N	Y/N	N		
Barrier Present?	Y/N	N	Y/N	N		
Intervening Rows of Buildings	number	0	number	0		

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: King Phillip Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	64	64	55
Source 1	61	60	52
Source 2	61	61	52
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	100	distance (ft)	100	
Daytime Hours	speed (mph)	70	speed (mph)	70	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	70	speed (mph)	70	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Longmeadow Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	52	51	42
Source 1	50	49	41
Source 2	47	46	38
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	300	distance (ft)	300	
Daytime Hours	speed (mph)	30	speed (mph)	30	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	30	speed (mph)	30	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Dean Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	61	60	51
Source 1	59	58	50
Source 2	56	55	47
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY

Noise receiver land use category (1, 2 or 3) 2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	75	distance (ft)	75	
Daytime Hours	speed (mph)	30	speed (mph)	30	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	30	speed (mph)	30	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Ingell Street

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RESULTS

Noise Source	**Ldn (dB)**	**Leq - daytime (dB)**	**Leq - nighttime (dB)**
All Sources	59	58	50
Source 1	57	57	48
Source 2	54	53	45
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	**Source 1**		**Source 2**		**Source 3**
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	100	distance (ft)	100	
Daytime Hours	speed (mph)	30	speed (mph)	30	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	30	speed (mph)	30	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	**Number**
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

Federal Transit Adminstration
General Transit Noise Assessment
Case: Hart Street

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RESULTS

Noise Source	Ldn (dB)	Leq - daytime (dB)	Leq - nighttime (dB)
All Sources	61	60	51
Source 1	59	58	50
Source 2	56	55	47
Source 3			

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for each noise source below - see reference list for source numbers.

NOISE SOURCE PARAMETERS

Parameter	Source 1		Source 2		Source 3
Source Num.	Diesel Loco.	2	Comm. Rail Cars	3	0
Dist. to receiver	distance (ft)	75	distance (ft)	75	
Daytime Hours	speed (mph)	30	speed (mph)	30	
(7 AM - 10 PM)	trains/hour	2.47	trains/hour	2.47	
	locos/train	1	cars/train	8	
Nighttime Hours	speed (mph)	30	speed (mph)	30	
(10 PM - 7 AM)	trains/hour	0.33	trains/hour	0.33	
	locos/train	1	cars/train	8	
Jointed Track?	Y/N	N	Y/N	N	
Embedded Track?	Y/N	Y	Y/N	Y	
Aerial Structure?	Y/N	N	Y/N	N	
Barrier Present?	Y/N	N	Y/N	N	
Intervening Rows of Buildings	number	0	number	0	

SOURCE REFERENCE LIST

Source	Number
Electric Loco.	1
Diesel Loco.	2
Comm. Rail Cars	3
RRT/LRT	4
AGT, Steel Wheel	5
AGT, Rubber Tire	6
Monorail	7
Maglev	8
Automobiles	9
City Buses	10
Commuter Buses	11
Rail Yard or Shop	12
Layover Tracks	13
Bus Storage Yard	14
Bus Op. Facility	15
Bus Transit Center	16
Parking Garage	17
Park & Ride Lot	18

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